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HOW LONG DOES A FLASH OF LIGHTNING LAST?

By A. C. Ranyard.

THE recent thunderstorms came most opportunely, while the information given in the last number was fresh in the minds of the readers of KNOWLEDGE. A great storm swept across England on June 2, travelling northward from the coast of Wiltshire, past Liverpool and Edinburgh, and up into Scotland. According to observations collected by Mr. Marriott, the storm centre travelled at the rate of 50 miles an hour, and was attended by violent electrical disturbances as well as the fall in some places of extraordinarily large hailstones, some of which, according to trustworthy reports sent to the Meteorological Society, measured 7 inches in circumference and weighed 7 ounces. On the evening of Thursday, June 6, London was visited by a great storm, which also drifted northward. Mr. H. S. Wallis, a statistically-minded observer, counted 1,244 flashes in two hours as seen by him from Highgate, which gives an average of more than ten discharges per minute.

Most observers of this storm agree that the flashes were generally multiple flashes; they either describe a pulsation about the light of the lightning, or state that they saw distinct flashes, sometimes four on five in number, travelling along the same course with a perceptible interval of time between them. To my eye it seemed that the first flash was generally the brightest, and that sometimes a flash was succeeded by a glow which lasted an appreciable part of a second. I saw no ribbon flashes and no dark flashes. There were a very few observers who thought that they saw both; we will deal with their observations later on.

Amongst the photographs that were taken on the 6th were several of the so-called "dark flashes," and several photographs of ribbon flashes. There are also some photographs which show three or four flashes which evidently travelled along the same course. Photographs Nos. 1 and 2 are of this description. It might at first sight be thought that these were photographs of parallel flashes; but an examination of the original negative shows in each case a triple image of a railway signal-post, and that the three images of the signal-post are separated by about the same distance as the three flashes. The three images of the post correspond in intensity with the three lightning flashes, and the displacement was in the same direction on the plate: so that, if the three images of the post were made to coincide, the three images of the flash would also coincide turn for turn and knot for knot. We can, therefore, hardly doubt that the plate shifted between the three flashes, and that the lightning really passed, in each case, along the same path of least resistance. This is more probable, when we come to consider it, than that there should have been three parallel flashes in the air, which followed one another at an even distance through all the irregularities of the sinuous course which lightning pursues.

Indeed, from the facts already at our command, we might expect that the first flash would heat the air and slightly rarefy it, leaving a course of least resistance, along which subsequent discharges would flow as certainly as water follows the twists and turns of a pipe. When the original negatives are examined, the evidence as to the shift of the plates in the interval between the three flashes is overpowering. The evidence which we are able to present to our readers is not so strong as that derived from the original negatives, owing to the faintness of the photographic images of objects which are only illuminated by the light of a lightning flash. At the bottom right-hand corner of photograph No. 5 the summit of the signal-box referred to above is shown. The camera hardly moved during this flash, and it will be noticed that each post is surmounted by a pointed ornament. Photographs 1, 2, and 5 were all taken from the same spot. The signal-box is also shown at the bottom right-hand corner of photograph No. 2, but the overlapping images are ghostlike and hazy. On the original negative the three images of the pointed summits of the posts and the distance between them can be measured, and is found to correspond with the shift of the image of the lightning flash. In photograph No. 1 the image of the signal-box is lost, but three images of it are distinctly seen on the original negative, and the direction of the shift of the plate can be determined with certainty. There is a faint gauze, ribbon-like structure, which joins the middle flash with the left-hand flash. It is rather more dense in places where the flash has been moved obliquely across the photographic plate, but the nebulous veil is so faint that I fear no traces of it will be shown in the photographic copies published with this. However, a somewhat similar phenomenon will probably be recognisable on photograph No. 2, when examined with a lens. The right-hand flash is nebulous on its inner or left-hand side, and the left-hand flash is also nebulous on its inner side, proving that the one flash began and the other ended with a glow. There are two other small flashes which can be traced running parallel with the three larger flashes. The whole system of flashes appear to have passed behind a cloud in their upper portion. Where they appear above the cloud they are fainter, but the nebulous character of the outer flashes is more easily recognised than below.

In addition to these photographs in which we have photographic evidence that the plate was shifted during the exposure, a most interesting photograph was taken by Dr. H. H. Hoffert, who intentionally moved his camera *to and fro* while he pointed it in the direction in which flashes

might be expected. Photograph No. 6, Plate I., is made from a transparency kindly lent me by Dr. Hoffert; it will be seen that similar flashes are shown upon the plate at a considerable distance apart, joined by nebulous filaments. Dr. Hoffert says, in a letter to Mr. Marriott:—"With regard to the questions in your letter, I can give you the following general account of the way in which the photograph was taken. I was standing on a balcony, the rain having ceased. The storm had approached close and was all around us. At the point to which the camera was directed were occurring numerous brilliant discharges, at a distance of, I should think, half a mile to the east-north-east of my house, which is close to Ealing Broadway Railway Station and on the Green. The flashes seemed to my eye single. The camera was moved to and fro so as to make a complete period in about three-quarters of a second. I have thus estimated the period between the discharges as somewhere between one-fifth and one-tenth of a second. The period that the plate was exposed was between a quarter and half a minute. The aperture was $\frac{f}{8}$, and a rapid rectilinear lens was used."

Dr. Hoffert has kindly lent me two transparencies from this photograph which, when placed one over the other and slipped from side to side, show that the three great flashes in the lower part of the picture are exactly of the same shape. They each have a double brighter head which, when magnified, shows a series of knots or beads. The parts of the flashes which turn suddenly away from or towards the observer leave the brightest traces joining one flash with the other. The question arises, are these traces due to a glowing of the incandescent air in the path of the discharge, or to the light of a series of smaller discharges which continue to find their way down the path of discharge in the interval between the great flashes. If the glow is due to incandescent air we should expect to find it gradually and evenly subsiding as the air or gases cool, and this is certainly not the case.

On the right-hand side of the lower part of the middle flash a series of increases and decreases in the brightness of the nebulous field due to the glow can be traced, showing that the glow varies in brightness between the flashes. The glow, whatever it is due to, lights up again and cools several times in the interval between the great flashes.

This has produced a very curious effect in the case of the upper flash, of which there are three images at the top of the photograph. The left-hand image is seen to have a black line down it. In fact it has been described as a dark flash. When examined closely with a lens it is seen to be bordered by a series of tufts parallel to the traces joining the flashes. These tufts correspond exactly in position with brighter beads or knots on the other two bright images of the upper flash. And the dark channel is seen to be a division between two somewhat brighter fields produced by a glow which followed in the minutest details the curves as well as the knots and beading of the brighter flashes. The channel, in fact, corresponds to a period when the series of smaller discharges down the path of the flash ceased. I do not assert that all dark flashes are of this character, but here we evidently have one means by which a dark channel curving in the characteristic manner of lightning may be produced.

It is worthy of remark that the dark flash shown in photograph No. 4 in the June number was taken on a plate which evidently moved during the exposure, as is proved by the superposed images of the roofs at the bottom of the picture. Mr. E. S. Shepherd, by whom the photograph was taken, informs me that the camera was held by the hand on a window-ledge, and it is quite clear that the camera moved between the flashes which illuminated the roofs, though Mr. Shepherd was unconscious of any movement. A similar remark also applies to photograph No. 2 in the June number, also taken by Mr. Shepherd. It is one of the ribbon flashes along which runs a black flash or channel following the sinuosities of a parallel bright flash at the upper edge of the ribbon. In this case the camera seems to have been moved in a vertical direction. Mr. Shepherd informs me that the camera was held by the hand on the edge of the window-sill, and directed upwards, and he is unconscious of having flinched when the flash came; but nearly two years have now elapsed, and his attention was not then specially directed to the matter.

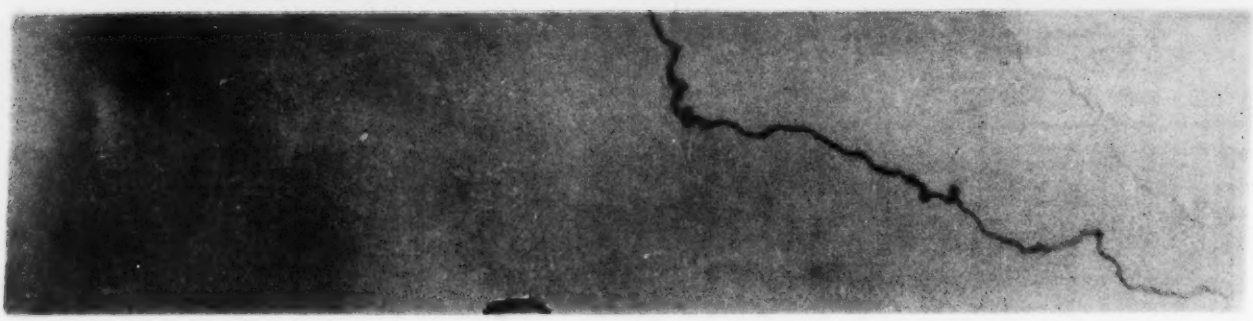
We rejected this theory of the origin of ribbon-flash photographs in the article in the June number, because we then believed lightning flashes to be as instantaneous as the electric discharges which can be experimented upon in the laboratory, and because it seemed that the striæ across the ribbon flash in photograph No. 1 in the June number were not quite parallel on different parts of the plate; but I have since had an opportunity of examining the negative of this flash, which was taken on a large plate, and I have satisfied myself that the want of parallelism is due to the optical distortion of the lens with which the photograph was taken.

As far as I have yet learnt, the photographs of broad ribbon flashes have all been taken with instruments held in the hand, or held against a fixed support, but not screwed to it. If we account for all the photographs of ribbon flashes by an assumed motion of the plate during the exposure, we are still confronted by the observations of those naked-eye observers who believe that they have seen ribbon flashes in the heavens. The observation must be a very difficult one to feel any certainty about. It is only since ribbon flashes have been photographed that a few observers think that they have seen ribbon flashes in the heavens, and we have to set against them a much greater number of observers who have watched for ribbon flashes during the same storms and seen none. It is very easy to deceive ourselves with respect to any observation which lies near to the limits of our senses—and there is another possible explanation. If the most sensitive part of the eye were not turned in the direction of the first flash, the eye would involuntarily turn so as to place the most sensitive part of the retina in the right direction; and if the second flash occurred before the image of the first flash had faded from the retina, it is very conceivable that an observer would suppose himself to see two parallel flashes. It is known that the sensitiveness of the retina of different persons for such after-images differs greatly, and hence such a phenomenon, though noticed by one, might not be seen by another. Similarly, the appearance of the dark flash would be accounted for by a coloured persistent image of a previous lightning flash remaining on a sensitive retina. We are all familiar with such after-images after staring at the sun; a sensitive eye may see them after looking at a lightning flash.

In addition to the broad ribbons referred to above, a narrow ribbonlike appearance may be caused at the edge of the plate by lenses which give very sharp images of ordinary objects; for lightning flashes are so bright that optical imperfections show themselves which would not affect the sensitive film around the image of an object of ordinary brightness. With the short focussed cameras in use, the pencils of light fall very obliquely at the edge of the plate, and the oblique sections of such pencils just beyond the focus frequently consist of a bright point with a nebulous tail, the shape of which varies greatly with the optical system used. Photograph No. 10 is an illustration of such optical distortion at the edge of the plate.

XUM

7 & 8. Taken at Dubuque, Ia, U.S. America, on the 17th of July 1887, by G. E. Davis.



9. Flash of lightning taken 31st July, 1887, by A. W. Nicholls, developed on Photograph of the Castle Mound, Fotheringhay, taken the next day.

10. Taken at Belsize Park, London, on 17th August, 1887, by W. Shuter. Enlarged two-and-a-half diameters.

Colonel Tupman has also sent me a negative of a lightning flash, showing a very distinct ribbon form at the edge of the plate, evidently due to considerable optical distortion. He has also sent me a beautifully sharp photograph of a landscape taken with the same lens set at the same focus. The examination of photographs of lightning flashes taken with instruments which have been well focussed affords an excellent means of studying the optical imperfections of the lenses employed.

But though the lightning flashes are bright enough to bring out the optical defects of the instruments, they are not bright enough (certainly as a general rule) to give rise to photographic reversal, such as would cause the line of the bright flash to appear dark upon the plate. I come to this conclusion for the following reasons. The photographic images of sparks taken in the laboratory do not show photographic reversal. The giant flashes in Nature's laboratory, of course, might do so, but none of the photographs of dark flashes I have seen show bright borders, such as one would expect to find, corresponding to the nebulous borders due to the optical imperfections of the instrument. Take, for example, photograph No. 8. If the light of the great branching flash were intense enough to cause photographic reversal at its centre, the hazy border at its edges would remain white. I have seen a paper print of one such dark flash with bright branches, which may possibly be due to photographic reversal; but one ought to have an opportunity of examining the original negative before coming to a definite conclusion. The mystery of the black flash cannot yet be regarded as completely solved. The further one proceeds in such an inquiry the more curious phenomena crop up, which need investigation. The bright beaded heads or knots in the air with which many flashes appear to commence are well worthy of study. Examples of such bright heads to flashes are shown in photographs Nos. 4 and 7, as well as in Dr. Hoffert's photograph.

Especial attention ought, during a future storm, to be given to measuring the time occupied by the phenomenon of a recurrent flash with a revolving cylinder or band of sensitive paper driven by clockwork, at a known rate, within the camera. In Dr. Hoffert's interesting photograph the great flashes appear to have the form of a narrow ribbon. One edge of the ribbon is quite sharp, and in the image of the great flash in the centre of the plate there is on Dr. Hoffert's photographic transparency (but not on the photographic copy published with this) a narrow line between the sharp edge and the remainder of the ribbon, as if the flash had consisted of an almost instantaneous discharge, and after a minute interval of time another discharge of considerable brightness, which lasted for a very short period, but still sufficiently long to show evidence of the motion of the plate. The dark interval between the flash and the ribbon shows that there was an interval of darkness, and that the ribbon cannot be due to incandescent air left in the wake of the flash.

A recurrent flash seems to be a very complicated succession of discharges lasting for an appreciable part of a second. The giant discharges which take place during a storm between irregularly-shaped and badly-conducting masses probably differ materially in character from the flashes produced in a laboratory between good conductors. In the laboratory the whole flow takes place at once. In nature there seems to be a flow or rush succeeded by a dribble, which ceases or nearly ceases, and commences again and again, flow after flow rushing down the same path until the potential along the line of discharge is equalised. There seems to be no evidence of a back rush or alternate backward and forward flash, as has been suggested. On Dr. Hoffert's photograph, and in our plates Nos. 1 and 2, and in the many ribbon flashes, all the parallel threads or flashes thin out in the same direction. If there were alternate flashes we should expect to find one thick at one end, and the next thick at the other. In Dr. Hoffert's photograph the left-hand flash of the lower series (which is the only branched flash on the plate) seems to have been the first in point of time, and the right-hand flash of the upper series of flashes seems to end with the black channel as an expiring effort.

The extreme rapidity of lightning has long been used as a synonym for that which is instantaneous. In our proverbial philosophy, "Quick as lightning" and "Like a flash of lightning" have been used to denote the explosive suddenness of changes which occupy less time than the twinkling of an eye. But we need measures of these things for a more exact philosophy.

NOTE BY MR. W. MARRIOTT.

I fully concur with Mr. Ranyard as to the photographs of ribbon flashes being due to a movement of the plate during its exposure to one of the recurrent flashes described in the second paragraph. As far as I am aware, no photograph of a ribbon flash has been obtained with a camera on a fixed support. The motion of the camera in photographs 1 and 2 is clearly proved by the superposed images of the signal-box, which seem to correspond in position and intensity with the different images of the lightning flash. An appearance of a narrow ribbon may also be produced by optical causes near the edge of the plate, where the pencil of light from the lens falls obliquely and the sensitive film is either beyond or within the focus; the section of the pencil of light is then not circular, but usually consists of a bright point with a nebulous tail, causing a hazy edge to the bright image of the flash. In these latter cases the ribbon character is not continued all across the plate, but the breadth of the flash and its hazy edging vary with the distance from the centre of the plate.

I also concur as to the multiple character of many of the flashes during the storm on June 6, and it seemed to me that the first flash was the brightest; this was succeeded by less brilliant flashes along the same course. In one instance I saw two flashes which appeared to me to be parallel, and separated by a dark interval. In this case the second flash was certainly the fainter. I am not sure that the apparent duplicity of the flash was not due to a motion of the eye, which would involuntarily be directed so that the second flash would fall on the most sensitive part of the retina, if in the first instance it had not done so.

TIGER-BEETLES.—II.

By E. A. Butler.

TIGER-BEETLES not only run with great agility, but readily take flight as well, and hence are rather difficult to capture; and as their eyes are prominent and can take in a wide horizon at one view they need to be very warily "stalked." The organs of flight are a pair of dark-coloured membranous wings (fig. 4), which, under ordinary circumstances, are packed away out of sight, beneath their green, horny covers. Being larger than their covers, they have to be folded up before they can be packed away; this is done twice transversely, the tip being bent round towards the base, and a second bend in the same direction then made higher up the wing, and then the two wings, as they lie along the back, partially overlap one another. Keeping these arrangements

in mind, and remembering that the insects are able instantaneously to start off through the air at apparently full speed, and with equal suddenness to arrest their course and alight on the ground, we see at once further illustrations of the extreme rapidity of movement of which they are capable. In order to commence flight, the wing-covers, or elytra, have to be raised and spread outwards, so as to liberate the wings, which in their turn have to be unfolded and expanded horizontally; but all these movements are performed so expeditiously that the eye cannot follow them, and the insect seems in an instant to rush into the full force of its headlong career. The elytra are kept extended during flight, but do not themselves take part in the operation, being simply raised to allow free play to the wings. The flight is not of long duration, but the beetle simply dashes away a short distance at break-neck speed, and then suddenly settles, all trace of the wings disappearing the instant it alights, if not the moment before.

FIG. 4.—WING OF TIGER-BEETLE.
The dotted lines indicate where the wing is folded.

There is a species called *Cicindela sylvatica*, larger than our common green tiger-bettle, of a deep violet-brown colour, and found pretty commonly on the heaths of Surrey, which takes somewhat longer flights than its green ally, though its movements are conducted in a similar manner. But on the other hand, our smallest species, *C. germanica*, found in *wet* places, especially at Blackgang, in the Isle of Wight, scarcely uses its wings at all, but employs itself in *running* about over the marshy ground it frequents. Some of the exotic *Cicindelidæ* are destitute of wings altogether, and are perforce confined to the ground. A few species in the tropics run about over the leaves of trees, apparently in pursuit of other arboreal insects. Some, again, are found on sandy seashores; belonging to this group is our own *C. hybrida*, a brownish insect, with a curved creamy band stretching partly across the elytra, and a few other creamy markings. It is the same size as *C. campestris*, viz., about half an inch long, and almost exactly the same shape. These maritime species are often protectively coloured. Bates mentions two tiger-beetles which he found on a sandy shore in America, one of which was of a pallid hue like the sand it ran upon, and could therefore readily escape detection. The other, however, was of a brilliant copper colour, and therefore exceedingly conspicuous; nevertheless it was as well protected as its obscure neighbour, for it was possessed of a strong and offensive smell, a mixture of that of putrid flesh and musk. The sand-coloured one, on the other hand, being sufficiently protected by its colour, was perfectly devoid of any such odour.

It is now time to say a word about the earlier stages of these insects. We will take for this purpose our common green species, *C. campestris*. The larvæ (fig. 5) are odd-looking creatures, and may easily be found in the situations frequented by the perfect insects. A number of circular holes will be observed in the ground, which are the entrances of their cylindrical burrows; from these they may, with a little care, be dug out. If a trowel be inserted in the ground some six or eight inches from one of these openings, into which a straw or stem of grass has been previously passed, so as to render the direction of the burrow evident even if the earth should fall in upon it, the burrow may be traced to its end, descending vertically to a depth of from six inches to a foot, according to the nature of the soil and the age of the larva.

FIG. 5.—LARVA OF TIGER-BEETLE.

Except in the jaws there is little resemblance between the larva and the adult insect. It is a whitish fleshy grub, with a broad, and what at first sight seems to be a decidedly *black* head. A lens, however, brings out the fact that what appears to be pure black is relieved by a dash of metallic green. In this extremely inconspicuous and almost invisible green we have the sole indication of the brilliant coloration destined to appear in the perfect insect; no doubt, however, the total absence of colour on the hinder parts is largely connected with the subterranean habits of the larva. The head is most strangely shaped; it is very hard, and its upper surface is rough and concave, the latter a most exceptional circumstance. Beneath it is the exact reverse of this, being highly polished and extremely convex, and of a mahogany brown colour (fig. 6). The segment immediately behind the head is equally broad, semicircular in shape, and covered above with a hard, horny skin, which is usually much encrusted with earth. The next two segments are similarly protected above, but are considerably smaller. All the rest are quite soft. The three shielded segments carry each a pair of legs, and are thus seen to correspond to the thorax of the adult. For a larva of this kind, the legs are much longer and thinner than might have been expected, a prophetic indication of the peculiarity that will characterise the limbs of the perfect beetle, and their apparent length is again increased by the placing of their point of attachment to the body almost at its sides instead of in the middle line, as is usually the case. The eighth segment after the head is surmounted by a large hump, which carries a pair of long hooks (fig. 7), which are movable, and can be erected and depressed at pleasure.

FIG. 6.—HEAD AND FIRST THORACIC SEGMENT OF TIGER-BEETLE.

FIG 7. — DORSAL HOOKS OF LARVA OF TIGER-BEETLE.

This brief sketch of the creature's form will have prepared us to understand how it makes its burrow and catches its prey. The eggs are laid by the parent insect where the larva will have no difficulty in selecting a spot for sinking its shaft. It begins excavating by nipping off fragments of the soil with its jaws, which, instead of projecting straight forwards or sloping down from the head as is almost universally the case, slant upwards, rising thus above the level of the margins of the concave head-surface. As the burrow deepens, a difficulty arises as to the disposal of the particles of soil removed. Then it is that the object of the peculiar structure of the head becomes apparent. While the animal is working with its head down in its burrow and its body projecting above, the fragments of sand and earth, as removed by the upward sloping jaws, fall on to the concave surface of the head, which is thrown back till it is at right angles to the body, to receive them as in a shovel or saucer. A load having been thus obtained, the grub backs out of its hole by means of its legs, carrying its little saucerful of earth with it. These operations are repeated till the burrow is of sufficient depth, the animal always working with its head downwards. When, however, the shaft is completed, the grub reverses its position and drops into the hole with its head upwards. It can then work its way up and down this vertical shaft, much in the same way as the chimney-sweepers' boys used to climb chimneys, using its legs and the hooks on the eighth segment to give it purchase against the sides of the burrow.

In order to catch its prey it posts itself at the top of the burrow, with its body in the shaft and its head and the semi-

circular segment behind just blocking up the entrance, and maintains itself in this vertical position by means of its legs and dorsal hooks. Here it remains in ambush, with jaws wide open, till some unwary insect comes within reach, when the head is violently jerked backwards and the prey seized by those relentless jaws with a tenacity of grip that renders futile all efforts at escape. The grub then hurries to the bottom of its den, dragging its prey with it; here it crouches, bending its body somewhat in the form of a Z, and devours its victim at leisure. As might be expected of an insect that trusts so much to chance for a meal, it is not at all fastidious, but will eat any living thing that comes in its way, not disdaining even its own species.

The exact length of time spent by the insect in this condition is difficult to estimate, and probably depends to some extent upon the abundance or scarcity of food. Larvæ, as well as perfect insects, may be found during a great part of the year, and the exact periods of its changes cannot be stated with any certainty. Like all other beetles, it becomes, when full fed, a helpless pupa or chrysalis; not a limbless thing such as that of a butterfly or moth, but more lifelike, inasmuch as the legs and other organs are apparent on the outside, though of course covered with a skin which renders them quite unusable. In this helpless condition it lies at the bottom of its burrow till ready to make its final moult, taking no food, but quietly effecting beneath its skin all those marvellous changes that are necessary to transform it from an unadorned, fleshy, crawling grub, into a hard-cased, brilliantly-coloured, flying, and predaceous beetle. Before becoming a chrysalis, it is said to guard against intrusion by closing the entrance of its burrow. When the bright spring weather comes round, it issues from its subterranean chamber in its perfect form, a sparkling, agile hunter, destined never to return to its hermit cell, but to spend the rest of its days basking in the sunshine, making war upon the other denizens of its ancestral bank, and laying the foundations of future generations.

PHOSPHATES AS FERTILISERS.

By D. A. LOUIS, F.I.C., F.C.S.

PHOSPHORUS in the free state is a highly inflammable and remarkably poisonous substance; it is familiar to every one as a material used in the manufacture of matches, and as a constituent of a paste for poisoning mice. When phosphorus is ignited in the air it burns with considerable briskness, evolving great heat and clouds of smoke. The product of the burning is a white substance, which dissolves readily in water, and has an intensely sour taste as well as other properties characteristic of a strong acid; it is, in fact, the substance known as phosphoric acid. By mixing this acid with an alkali or base, such as soda, potash, or lime, all the acid properties and the sour taste disappear, because the phosphoric acid and the base become intimately and firmly attached to one another, forming a compound having neutral properties and known as a "phosphate." In this form not only is the phosphorus non-poisonous, but it even becomes an essential constituent of living matter, and neither animals nor plants can thrive unless they receive a proper supply of it. Phosphates must therefore be included in our food. We either directly (as from bread and vegetables) or indirectly (through meat or the flesh of animals feeding on vegetation) obtain our supply of phosphates from the vegetable kingdom; therefore, in order to discover the source of our own phosphate supply, we must learn which plants contain phosphates, where they get them from, and how they get them. The existence of phosphates in plants is easily demonstrated, for when a plant is burnt the phosphates remain in the ash, and numerous careful analyses of plant ashes have enabled chemists to ascertain the average amount present in different plants. The numbers representing the average quantity of phosphoric acid present in some of our most useful crop plants are arranged in the second column of the following table, and in the third column are given the numbers representing the average quantity of ash which remains when 100 lbs. of the various plants are burnt; whilst the data in the fourth column show how much of this ash consists of phosphoric acid. In the first column are placed the names of the materials to which the various numbers relate. It is interesting to notice how each plant collects a different amount of phosphoric acid, and disposes of most of it in such a way as to be of use to succeeding generations of the plant. Thus the largest proportions of phosphoric acid are accumulated in the seeds; or when the roots store up nourishment, as in the case of turnips and potatoes, the preponderating quantity of phosphoric acid is found in the roots, which if left in the ground would serve as a store of food for the future development of the plants.

	100 lbs. of the substance named in the first column contains the following quantities of		100 lbs. of Ash from the substance named in the first column contains the following quantities of Phosphoric Acid.
	Phosphoric Acid.	Ash.	
	lbs. oz.	lbs. oz.	lbs. oz.
Wheat, grain	12¾	1 11	46 3¼
„ straw	3½	4 9¾	5 6½
Barley, grain	12¼	2 3½	32 13
„ straw	3	4 2	4 5
Pea, grain	13¾	2 5½	36 5
„ straw	5½	4 6½	7 13
Field beans, seed	1 3	3 1	39 3
„ straw	5¼	4 6¼	7 13
Potatoes, tubers	2½	15	19 1½
„ haulm	2½	1 15½	5 8
White turnips, root	1½	11¼	17 6½
„ leaves	1½	1 3	8 14½
Mangels, root	1	12	9 9¾
„ leaves	1¼	1 6½	5 1¾
Meadow hay	6½	5 2⅓	6 3¼

All these plants, and in fact all plants, obtain their phosphoric acid from the soil, and insignificant as the amounts appear in the above table, nevertheless, when the total weight of crop is taken into consideration, the real magnitude of these quantities soon becomes manifest. It is found, for instance, that a crop of wheat yielding 30 bushels of grain per acre will take from the soil a quantity of phosphoric acid which would be represented by a dressing of over 140 lbs. per acre of a rich superphosphate containing 25 lbs. of soluble phosphate in every 100 lbs. In a similar manner a crop of barley yielding 40 bushels per acre will remove phosphoric acid equivalent to a dressing of nearly 140 lbs. per acre of this rich superphosphate, whilst the phosphoric acid removed by a crop of 6 tons of potatoes, or 17 tons of turnips, or 22 tons of mangels per acre, would be represented respectively by dressings of 162, of more than 220, and above 350 lbs. per acre of the superphosphate.

And the farmer has to produce at the present time such crops as these, or even larger ones, in order to make things pay. It must be remembered, too, that most of the phosphoric acid removed from the soil in these crops is irretrievably lost to it; for except when crops are used for

feeding cattle, horses, &c., only those portions poorest in phosphates are utilised on the farm for litter, &c., and subsequently find their way back to the land in the form of farmyard manure; whereas the richest portions of the crops, such as the seeds of most cereals, and edible peas and beans, the tubers of potatoes, and a good share of the roots and hay in the form of meat, are sold off the farm for human consumption, and then the phosphates, along with many other valuable constituents, find their way in the majority of cases to the nearest stream or river, and ultimately to the sea. The quantity of valuable material lost in this way is enormous.

If the supply of phosphates available for the plant falls short, then the plant thrives badly, and yields light crops and inferior produce. As an example of this, some data are arranged in the next table, embodying results obtained by Sir John Lawes and Professor Gilbert at Rothamsted. In the first column are given the names of the crops; in the second the average weights of the yield of these crops when grown on a soil containing only a small quantity of phosphates, but receiving an abundant supply of nitrogenous manure; in the third column are given the average weights of the yield of the same crops, on the same soil, with the same quantity of nitrogenous manure, and, in addition, a supply of phosphates; in the fourth column are shown the increases in crop yield obtained by supplying the requisite phosphate:—

Crops.	Yield per acre, when grown on the same soil, with ample supply of Nitrogen.		Increase in yield per acre obtained by the use of the superphosphate.
	With insufficient supply of Phosphates.	With plenty of Phosphates as superphosphate.	
Wheat . .	3,274 lbs.	4,204 lbs.	930 lbs.
Barley . .	3,374 „	5,006 „	1,632 „
Hay . .	3,220 „	4,564 „	1,344 „
Turnips . .	1,792 „	10,194 „	8,402 „
Potatoes . .	5,334 „	17,192 „	11,858 „
Mangels . .	19,936 „	25,088 „	5,152 „
Sugar-beet .	29,008 „	35,728 „	6,720 „

The figures speak for themselves as to the amount of the harvests. The quality of the produce is also improved, for example, in the case of potatoes; the percentage of good tubers is 91 with and 85 without the superphosphate. This table illustrates another point—a point to which attention was drawn in the concluding lines of the article on "Nitrates" in the March number of KNOWLEDGE, p. 102, and which refers to the imperfect utilisation of nitrogenous manures in the absence of other plant-foods in the soil; it must, however, be borne in mind that the above increase in crops is obtained by the addition of only two important constituents of plant-food, viz., phosphoric acid and calcium. Nevertheless, the quantity of nitrogenous manure rendered active by them is very striking.

Having thus far shown the necessity and the advantage of supplying plants with phosphates, attention will now be turned to the sources of the phosphates for the supply of plants. And here we observe one of those interesting and wonderful compensating influences which are at work everywhere in nature; for the supply of phosphates for plants is largely, almost entirely, derived from animals past and present, so that in this way animals return to the soil material in a form useless to themselves but upon which plants thrive vigorously and reconvert into a form which is then available for the requirements of animal life.

The first and, as regards origin, the simplest supply of phosphates for plants is found in farmyard manure, stable-litter, sewage, and such like matters which are mainly the rejected products of living animals. The animal consumes in its food amounts of phosphoric acid considerably in excess of its requirements, and consequently when passing through the body this excess is not digested, and is ultimately rejected by the animal along with other indigestible matter and waste products produced in the animal organism. These supplies of phosphates are therefore much mixed up with all sorts of other material, and in fact contain only a small proportion of phosphates. The next source of phosphates is the dead animal, and, as in the case of plants, the phosphates are found in the ash. Now flesh contains (speaking very generally, for all kinds of flesh differ to a certain extent in the amount of ash) about 4 to 6 per cent. of ash; bone, also speaking generally, contains 60 to 70 per cent. of ash; it will therefore be seen that the latter parts of the dead animal would naturally be looked to to supply most phosphates.

Bone consists of both organic matter and inorganic matter or ash constituents. If a bone is allowed to soak in dilute hydrochloric (muriatic) acid, all the ash constituents are dissolved out, and the bone, while retaining its original shape, becomes translucent and soft, and in fact is then nothing more than a lump of jelly mixed with some fat. If, on the other hand, a bone is boiled in water, it loses all the fat present in it and some gelatin (jelly). This fat is used for making candles; the gelatin for size. By steaming the bones in closed vessels a further quantity of gelatin is extracted and furnishes a kind of glue. By subjecting bone to a still greater heat in a retort over a fire, most of the organic constituents distil off, forming what is known as Dippel's oil, and a residue of carbonised organic matter, "animal charcoal," is left in the retort. But by burning animal charcoal or fresh bones in the air, all the organic matter is consumed and the ash only is left behind. When bones in these different stages are examined chemically the amount of phosphates they contain nearly approaches the following quantities:—

100 lbs. of	Contain lbs. of Phosphates
Fresh bones	50
Boiled bones	50 to 60
Steamed bones	60 to 70
Animal charcoal . . .	70 to 80
Bone ash	80 to 85

However, as might be expected, bones in all these states show great variation in the quantities of phosphates they contain, but the value of bones as a phosphatic manure follows the order above given, bone ash being the best.

In nature, wherever animal matters accumulate they suffer changes in an order closely resembling that described above in the artificial treatment of bone; first the most delicate and volatile parts suffer decay, then the tougher portions, until the bones alone remain; then the bones decay in a similar manner until only the ash constituents remain.

In past ages such deposits have accumulated, and we find the bones buried in the earth; they have retained their shape in many cases, but almost always all the organic matter has gone, its place being taken by mineral matter. The deposits are dug up and the material comes into the market as fossil bones; large quantities come from South Carolina in the United States, also from Cambridgeshire, Buckinghamshire, and Suffolk, in England, from the North of France, and elsewhere. Sometimes the fossils have almost entirely disappeared, and the remains have become intimately mixed with the rock; such is often the case in the Belgian deposits near Mons, in some of the deposits in the North of France, and in other deposits in the neighbourhood of Bordeaux, in Nassau in Germany, and in the west of

Spain. In fact, in the three latter localities, extensive masses of mineralised phosphate known as "phosphorite" occur.

Sometimes phosphates are found in a highly mineralised condition in well-defined crystals, which have evidently been deposited from solution in the rocks where they are found. Such phosphates are found in old rocks in Canada and Norway, also in Spain, and are known as apatites; they consist of calcium fluoride and phosphate, and sometimes, as is the case with Norwegian apatite, of the chloride as well. The crystals sometimes are of considerable size: some very big ones from Canada were exhibited in the Indian and Colonial Exhibition, and looked like hexagonal pillars artificially shaped.

Other sources of phosphate for the farmer are the guano deposits. They mainly originate from the excretory deposits of sea birds; when fresh or in protected places the deposits contain much organic matter, and consequently nitrogen as well as phosphates, but in old deposits or in places exposed to severe atmospheric influences, heavy rains, heat, &c., the organic matter has disappeared and only inorganic matter remains, which in course of time becomes washed into and mixed up with the rock. Nitrogenous guanos are found on the islands near to and on the coast of Peru, in Patagonia, and the Falkland Islands in South America, and on the islands of Ichaboe and Ascension in Africa. Guanos containing phosphates but no nitrogen are found on many of the West Indian islands, in Mexico, on some of the islands in the South Pacific Ocean; also on the Kuria-Muria islands in the Arabian Sea; in New Guinea, Australia, &c., &c. In some localities the guano is found deposited along with other animal remains, and bones, teeth, and shells are found mixed up with it. Curaçao and Barbadoes guanos are of this type.

Coprolites consist of nodular, spherical, and irregular lumps of phosphate, which are dug out of the earth in Cambridgeshire, Buckinghamshire, Bedfordshire, and Suffolk, in England. They are also found in the north of France, in Russia, and in Austria. They are supposed to be the fossilised excreta of huge extinct lizard-like animals, but in the majority of cases there is little or no evidence to support this supposition.

All the natural phosphates that have been here considered are insoluble, or practically so, in water; they cannot, therefore, in the raw state be easily distributed in the soil so as to be accessible and useful to the plants. Fortunately, however, simple treatment with sulphuric acid (oil of vitriol) converts them into a soluble form of phosphate and gypsum; such mixtures contain all the other fixed constituents of the original raw phosphate, and are known as superphosphates. The phosphate in superphosphates is mostly soluble, and, when applied to land, is washed into the soil by rain, and becomes well distributed throughout so as to be readily accessible to the plant roots; in contact with various soil constituents it, however, soon again assumes an insoluble form, and is, therefore, not washed away like nitrates. Before concluding, a word or two must be added about a source of phosphates which cannot be considered of animal origin. Until the year 1879 iron obtained from ores containing phosphates even in very small quantities, as a great many iron-ores do, could not be used for the manufacture of steel because the metal retained the phosphorus, which contributed undesirable and deteriorating properties to the steel. In the year 1879, however, Messrs. S. G. Thomas and P. G. Gilchrist made known to the world their discovery of lining the vessel in which the iron is melted to convert it into steel with lime, or a mixture containing much lime, and also adding lime to the molten metal. This produces wonderful changes, the lime combines with the phosphorus to form phosphate, which then separates from the mass of molten metal and floats on the top along with other impurities, forming what is known as "basic slag." By this discovery much material, which had hitherto been useless for the purpose, could be employed for the manufacture of that extremely valuable material, steel, the quality of which was greatly improved by the removal of the phosphorus. What is more, this phosphorus, which was formerly not only absolutely useless but also a nuisance, is converted in this "basic" method of making steel into a valuable source of phosphate for the supply of that all-important plant constituent to our crops.

OUR MICROSCOPIC FOES.

By A. WINKELRIED WILLIAMS.

OF all the foes that are waging war against mankind the most dangerous and deadly are minute organisms belonging to the lowest orders of plant-life, and invisible to our naked eye. An immense number of these always surround us, and are ready to make an attack should they find a weak point in our defences.

Their presence in the air may be readily demonstrated by exposing some material upon which they can feed, and watching the result. The simplest method is to boil a potato, cut it in half, and immediately place one half under a bell glass purified by being washed in an antiseptic solution such as corrosive sublimate. Expose the second half to the open air for a short time, and place it also under a glass. Let them remain for a few days, and then examine. If the first half has been placed rapidly enough under the glass, we shall find it unaltered. On the second half, however, we shall see a number of small but growing spots, which will probably vary much in colour. These consist of colonies made up by immense numbers of the most minute plants, i.e., bacteria, and also of higher fungi. Certain species of the bacteria constitute our dreaded foes.

Bacteria are non-nucleated unicellular plants, which may be roughly classed into two divisions according to their shape, the circular forms being called micrococci, the elongated forms bacilli. In size they are most minute, being only visible under the highest powers of the microscope. Many are provided with cilia, by the lashing of which they are capable of independent movement. They are composed of a peculiarly resistant protoplasm, which is condensed at the surface, so that by the action of certain caustics they can be separated from many tissues on which they may be lying, the caustics destroying these tissues.

Bacteria have enormous power of reproduction, which is accomplished by division of the cells and fission. Many also form globular spores by a condensation of their protoplasm. The spores have a much higher power of resistance than the bacteria themselves, and may, under unfavourable circumstances, be quiescent while awaiting better times to take on full development.

Their *habitat* is almost everywhere. In water bacteria exist in great numbers; they are even found in springs at their sources. This indicates their presence in the soil, where they are found in great numbers. We have already seen that they exist in the air; but, being, for their size, heavy bodies, they are invariably attached to less dense particles of dust. Out at sea we find the air free from bateria, although in the water they abound. The higher we ascend the fewer we find. In towns the air teems with them, in the country but few exist. In the healthy living

body there are no bacteria, except in the alimentary canal and upper respiratory passages. It must not be supposed that all bacteria are the forerunners of disease; such is the case with only certain forms to which the significant term *Pathogenic bacteria* is applied. Many authorities assert that the non-pathogenic forms may, under certain circumstances, develop into pathogenic forms. This, however, has not been definitely settled, since we are only able to separate the different classes of bacteria by their action on cultivating media and on the living body. We have not yet been able to develop by cultivation a virulent form from a non-virulent, although we have by repeated cultivation diminished the virulence of some of the most malignant bacteria.

Of all the *Pathogenic bacteria* we have the most direful tale to tell. Of one discovered by Dr. R. Koch—namely, that of tubercle—the terrible ravages on human life by ferocious animals in India (over 24,800 fatalities per annum) are but trifling compared to the ravages stealthily done in our midst by this the smallest of the class of most minute living units. According to Dr. Koch's estimate one-seventh of the human race die of pulmonary consumption, and this is only one, certainly the most prolific, of the many diseases directly caused by the tubercle bacillus.

Happily for warm-blooded animals, these terrible death-dealers differ from most other bacteria, for although they can remain alive for some time outside the body, they are unable to *develop* in the outside world, and this considerably limits their number. A temperature above 96° Fahr. is necessary for their growth, and there are only a very few soils on which they can be cultivated, such as blood-serum and meat jelly. Moreover, they develop more slowly than other known bacteria, which may consequently outgrow them, and prevent their development. How, then, are we to account for the fact that tubercle is such a widely-spread disease, not only among all the races of men, but also among many of the lower animals? The consideration of the following facts answers this question.

The tubercle bacillus can form resting spores; consequently when once the tissues of a part have their vitality so lowered that the entrance of the bacilli is allowed, they can retain their hold with great tenacity. Although the bacilli cannot develop outside the body, their vitality is preserved for a long time; they have been found active in dried sputum as many as 180 days old. The sputum of consumptive patients swarms with bacilli, and great carelessness is often evinced in dealing with this. Certain animal products used for food, such as the milk of tubercular cows, contain the bacilli. Experiments, such as causing animals to inhale the tubercle bacilli, or the introduction of them into the blood, or sometimes the feeding on tubercular matter, result in tuberculosis.

Pulmonary consumption presents an example of the most typical way in which the tubercle bacillus performs its deadly work. In the majority of cases the bacilli are inhaled with the air, but may also infect the lungs by the blood carrying them from tuberculosis in other parts of the body. The bacilli are incapable of independent movement. This difficulty is too readily overcome in the body, as the streams of blood and lymph easily carry them along.

Their movement in the body may be aided by certain scavengers that are crawling about in our tissues and circulating in our blood, namely, the wandering cells of connective tissue and the white blood corpuscles. These take up the bacilli by wrapping their substance around them; then for a time they crawl about carrying with them the bacilli. In this attempt to devour the tubercle bacillus they often find they have caught a Tartar, who in turn feeds on and multiplies in them, and thus their wandering days soon end.

The bacilli and their secretions cause great irritation in the cells containing them, and also to the tissues around; as a result of this a most erratic growth of cells occurs, which pushes aside and causes atrophy of the normal tissues, thus forming a tubercle nodule. Blood-vessels do not form in the nodule; the central cells, deprived of their nutriment, and irritated by the secretions of the bacilli, die and coagulate into a cheesy mass, whilst at the periphery of the nodule the growth continues, and may join other nodules. In the cheesy centre the bacilli remain for a while, and their spores, when present, for a much longer time.

By-and-by one of these nodules may become softened, and work its way into an air passage, and the mass of tissue may be either coughed up or be drawn down as a fresh focus of mischief to other parts of the lung. As a result of this, if the nodule be large, a cavity is formed, which increases in size and joins other cavities. Blood-vessels may be broken into, causing bleeding and general infection of the system.

In this way a fatal state of affairs is brought about.

Tuberculosis may infect all parts and organs of the body, the process varying somewhat with the structure of the organ affected.

Many other diseases are also known to be caused by bacteria, such as anthrax, cholera, pneumonia, typhoid fever, erysipelas, leprosy, suppuration, and ordinary blood-poisoning. Before Sir Joseph Lister introduced the system of antiseptic surgery, bacteria were a most fertile source of danger in surgical operations by the decomposition and suppuration they set up in the wounds.

In this short paper it is impossible to describe the characteristics of any other pathogenic bacteria, but perhaps enough has been written to show the great danger to which we are exposed from attacks by an immense army of minute foes. Our defences against these will be the subject of another paper.

ON EARTH-WORMS.

By E. MANSEL SYMPSON, M.A., M.B., Cantab.

LET us start by tracing the young earth-worm from its egg to adult life, we shall then see the relations of the stages through which it passes to other forms of animal life, and we shall get clearer ideas of the several parts and organs of the adult earth-worm. At starting, like everything else in the animal and indeed vegetable kingdom, the fertilised egg of the earth-worm is a mere tiny mass of jelly-like protoplasm—a peculiar compound of carbon, hydrogen, oxygen, and nitrogen, which has never yet been obtained save as a product of living bodies, and which forms the basis whence all organs, nay all cells, in the living world have sprung. This mass of protoplasm is called a cell, and has a smaller mass of somewhat altered protoplasm and nucleus inside it. It is laid in a case or cocoon, of somewhat the same structure as a beetle's wing, which has probably been secreted by a large gland in the upper end of the earth-worm's body. Soon the one cell begins to divide into two, and these into four, and so on, till, eventually, what was the egg-cell consists of a great number of cells, all, however, just alike. In the next stage these cells become arranged in two rows or layers, and all of those in one layer are larger than those in the other. The little animal so formed becomes concave, hollowed out on the side formed by the larger cells, until it assumes the form of a sac, with an opening—the future mouth—at one end, the cavity of the sac being the primitive alimentary canal, lined

by the large cells, called the hypoblast, while the small cells, known as the epiblast, form a kind of primitive skin round the animal, and possess each little filaments called cilia, serving for locomotion. These two layers pass

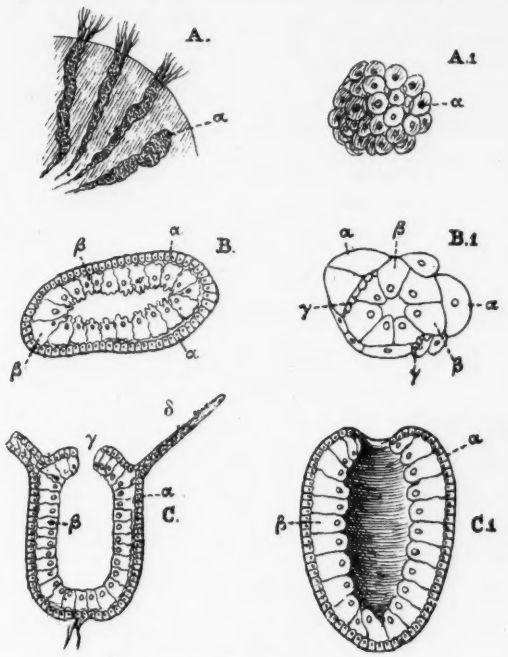


FIG. 1.

A. PROTOZOON-OPHRYDIUM. α, retracted. A1. EARTHWORM, 1st stage. α, nucleus. B. METAZOON—HYDRA, transverse section through body A-B. α, ectodermic or epiblastic cells; β, hypoblastic cells. B1. 2nd stage, transverse section. α, epiblast cells; β, hypoblast; γ, mesoblast. C. Longitudinal section. α, epiblast; β, hypoblast; γ, mouth; δ, tentacle. C1. Vertical section. α, epiblast; β, hypoblast.

into one another at the oval, or mouth-opening. The outer layer is the organ of support of locomotion (by the cilia) and may be the seat of the respiratory functions. Let me here remind you that the frog—so highly developed compared with our earth-worm—under certain conditions breathes largely by means of its skin. Also, in so far as this outer cell-layer perceives the state of the surrounding medium—that is, the air, water, or earth wherein it dwells—it is an organ of sensation too. The inner layer is nutritive in function; it produces changes in the food which is taken in, and allows what can be turned to useful account to pass into its cells, and these in their turn feed the outer layer of cells. What is useless is passed out again by the same opening whereby it entered. As the functions of the two layers are different, so also the form of the cells differs in each layer. And here we may pause for a moment to compare these stages with what we know of the animals lower in the scale than earth-worms—*i.e.* the Protozoa and the Cœlenterata. One great law of development is this: that each animal, in the commencement of its separate life, passes through stages which are permanent among animals lower than itself. There are two great classes of animals: the Protozoa, which includes the Amœba, the Infusoria, and the like; and the Metazoa, wherein are all other kinds of animals. One of the facts which mark off the first class from the second is that a protozoon may consist of any number of cells; but those cells are not different from one another either in form or function. It is very interesting to compare one of these, say ophrydium, with the earth-worm's egg in its early stage. In both you will find many cells cohering together, but in neither will there be the least difference in the cells themselves or in what they do. This process of cell-division in the egg may therefore be explained as a survival transmitted from early ancestors. Now the metazoa are characterised by having at least two layers of differentiated cells in their embryos. There is the cœlenterata, which contains the common hydra of ponds, the fresh-water polyp, the jelly-fishes, and the sea-anemones. Let us take one of these, say a hydra, and set it beside our young earthworm, this bag, with its double layer of cells, for a coat, and we find that, as far as form and functions go, they are almost the same. Our hydra is nothing else than a stomach-bag with a double coat, set on a stalk and furnished with tentacles. There could hardly be a better illustration of the law of development I have just mentioned. Later on, a third layer of cells may be seen, the mesoblast, between the other two.

It is a universal rule that from the outer layer of cells (the epiblast) are derived the whole of the nervous portions of an animal's body, as well as the skin and the lining membrane of the mouth, while from this mesoblast, or middle layer, come the muscles, bones, connective tissue, and the like. From the hypoblast is derived the epithelium of the alimentary canal and of all the glands which are in connection with it, such as the spleen, liver, and pancreas.

Very soon the mesoblast of our young earth-worm on one side of the bag-like structure becomes divided into a number of square masses, disposed quite regularly on each side of the middle line on the under surface of the animal. Also, along this line, the outer layer of cells

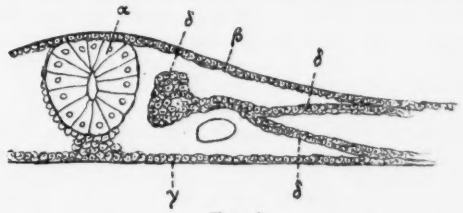


FIG. 2.

α, nerve cord; β, epiblast; δ, mesoblast; γ, hypoblast.

thickens upwards and inwards, and from this is formed the nerve-cord which runs the whole length of the body. From it is derived the brain and spinal cord of a mammal. At the same time, each of these square masses becomes hollow in the centre, and somewhat like a sac itself. The adjoining walls of each of these sacs fuse together, and here you have a trace of the division into segments, which is common in the animal kingdom, and which is shown in man by the transverse bands across the abdomen. These sac walls are represented outside on the body of the earth-worm by the transverse rings. On the under surface of the first segment is the mouth; we distinguish one surface from the other by the lighter colour of the lower one, and because on it in each segment are four pairs of hairs or setæ. These are of great importance to the animal; by their aid it can get over the ground at a tolerably rapid rate, and when once partly in its burrow, it holds so fast that it cannot be pulled out without being torn in pieces. I mentioned the gland—the clitellus—it shows as a thickening of the skin between the twentieth and thirtieth segments. This secretes a kind of viscid gumlike fluid, which hardens and envelopes the egg like the case of a cocoon. Let us now look at the digestive system by the aid of the following diagram. At the upper end you find the mouth, with a sort of lip to it, which is useful for catching hold of food. Next comes a strong

XUM

muscular pharynx, which is pushed forwards as the animal eats. Below this the canal narrows into the gullet—the œsophagus, into which open three several pairs of glands, secreting a surprisingly large quantity of carbonate of lime. Nothing like them is known to exist in any other animal. They are very richly supplied with blood, so that at first sight even one feels sure they must serve some important purpose in the animal's economy. That purpose is probably twofold in character; they serve as organs of excretion, that is, to cast out of the body something which is useless or actually harmful; and secondly, they directly aid digestion. You will almost always find an accumulation of carbonate of lime, sometimes in crystals, sometimes in little almost shapeless lumps, and you don't find those worms which live in chalky soils and whose intestines are full of chalk, with smaller or less well-filled glands, so we may fairly argue that the lime is an excretion. Again, worms live largely on fallen leaves, as we shall see presently, and these contain a large amount of lime, of no use to the tree, which gets rid of it in this way. Secondly, the half-decayed leaves generate in themselves various kinds of acids; the secretion of the earth-worm's alimentary canal is alkaline, and it is believed that these masses of lime neutralise the acid food so as to allow the alkaline secretion to have fair play. On passing on from these glands one finds that the canal swells out into the crop, and a little lower down into the gizzard, which the worm uses as a fowl uses its gizzard to crush and reduce to a pulp hard food. To assist this, the bird swallows gravel and small stones. Our earth-worm has no teeth, and not even a beak; its gizzard is formed of very strong circular muscles, and generally encloses a store of sand and tiny stones. From the gizzard, the intestine, which has a number of dilatations on each side, runs in a straight line to the vent at the posterior end of the body. From its upper surface all along proceeds downwards into it a dip or involution—the typhlosole—serving to extend the absorbent surface very greatly. The nervous system of the earth-worm is very simple. In the third segment, overlying the pharynx, are two ganglia united together; from these nerves run to the mouth and skin of the first segment. These ganglia are supposed to represent the brain of a higher animal. From these, two nerve-cords run round the pharynx to the ventral surface of the intestine; they join there, and run the whole length of the body, swelling at every segment into a ganglion-form enlargement, whence two pairs of nerves are given off on each side, while from the intermediate nerve-cords one pair supplies the deep muscles. We may consider this ventral nerve-chain as comparable to the spinal cord of higher animals, while a tiny nerve-filament—the so-called stomato-gastric—coming from the supra-œsophageal ganglia dorsally over and to the intestine, is the equivalent of the sympathetic system. With regard to the vascular system, there are two kinds of blood in the earth-worm. Mr. Busk put forward the ingenious idea that in the blood of mammals there may be a division made into two functional parts, *i.e.*, that of the red corpuscles, which are carriers of oxygen, and the white corpuscles and plasma, conveying nourishment to the tissues. This idea has also been supported with his accustomed vigour by Ray Lankester. In the vessels of the earth-worm *red* blood is very extensively supplied to the skin (a breathing organ), while a colourless plasma with white cells in the segmental chambers bathes all the visceral organs. The division of function which has been suggested is rendered probable by the analogy of the worm, though not certainly proved. As regards the blood-vessels, a dorsal one—rhythmically contractile—runs the whole length of the animal's body; there is also a sub-intestinal and a sub-neural one, all of which communicate with each other, and in the eighth to the sixteenth segments these communications are called hearts.

(*To be continued.*)

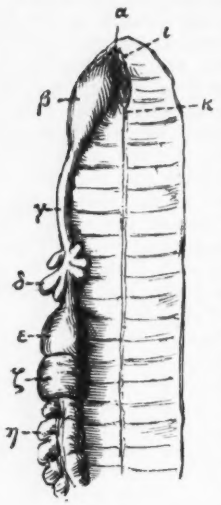


FIG. 3.
From a dissection.
α, mouth; β, pharynx; γ, œsophagus; δ, calciferous glands; ε, crop; ζ, gizzard, η, intestine; ι, supra-œsophageal ganglia; κ, double nerve-cord.

SOME PROPERTIES OF NUMBERS.

By ROBT. W. D. CHRISTIE.

TAKE any multiple of 7 having two digits only, then we may place any other figure on each side, and the number with four digits thus obtained will also be a multiple of 7: *e.g.*, suppose we take 21 or 28 or 35, then 1211, 2212, 3213, 4214, 5215, 6216, 7217, 8218, 9219, &c., are all multiples of 7; so also 1281, 3283, 5285, 3353, 4354, 6356, &c., are divisible by 7 without remainder.

The same principle applies to multiples of 11 or of 13: *e.g.*, let us take 33, 55, 77; 26, 52, 78. Then the numbers 1331, 4554, 6776; 4264, 7527, 9789 are multiples of 11 and 13 respectively.

The same principle applies to numbers having *eight* digits (or 6m−4 digits): *e.g.*, 12345676 is divisible by 7; consequently 1123456761, 2123456762, 3123456763, &c., are also divisible by 7.

We need not confine the principle to numbers of two or eight digits: *e.g.*, we know that 567 is divisible by 7; so also is 14679. Here I place 9 on the right side, according to the rule, but instead of placing 9 on the left side I add 9+5 to get 14. Again, 234 is a multiple of 13; so also is 9347 for the same reason. Again, 2678=13M; so also is 31785. Here 26+5=31, and so on for any number of digits. The figure placed on each side need not necessarily be the same. Any figure of the *same form* will do equally as well. Thus 8211, 2219, 17213, 144214, &c. Here 8 is of Form 7M+1, 144 of Form 7M+4, &c. In applying this principle, though we may have any number of figures on the *left*, we are restricted to one figure on the *right* hand. The proof is easy. Let N=7, 11, or 13.

We have $10b+c=N(M_1)$ by hypothesis.
Therefore $10^2b+10c=N(M_2)$ . . . . . (1)
Also $10^3a+a=1001a=N(M_3)$ . . . . . (2)
Thus $10^3a+10^2b+10c+a=N(M)$. Q.E.D.

(2) If we take any number with 6 digits (or 6n digits), having remainders 1, 2, 3, 4, 5 or 6 when divided by 7, we may by prefixing 6, 5, 4, 3, 2, 1 respectively obtain an exact multiple of 7: *e.g.*, the number 123456÷7 has a remainder 4. Therefore 3123456=7M. Here we have 7−4=3. Again, 123456, when divided by 13, has 8 for remainder. Therefore, since 13−8=5, we have 5123456=13M. Similarly, 123456789012=13M+11. Therefore 2123456789012=13N.

(3) Take any number of two digits and double it. The four figures placed side by side are divisible by 17.

Thus 1224, 3570, 4692=17M.

If we proceed, as in (1) *supra*, we need not confine the principle to figures of two digits. Thus $53\times2=106$.

Therefore 5406=17 M. Here $53+1=54$.

Again, $1234\times2=2468$. Therefore

$$\begin{array}{r} 2468 \\ 1234 \\ \hline 125868=17\text{M}. \end{array}$$

If we take care to leave untouched the two figures on the right, and place the other figures, as in the example, the principle will extend to any number of digits. This is easily proved thus:—Let t signify *ten*.

Then $(at+b)(t^2+2)\equiv 17\text{M}$,

i.e., $at^3+bt^2+2at+2b\equiv 17\text{M}$. Q.E.D.

Also, since $(at^2+bt+c)(t^3+3)\equiv 17\text{M}$,

Therefore $at^5+bt^4+ct^3+3at^2+3bt+3c\equiv 17\text{M}$.

This means that if you multiply a number of *three* digits by 3 and place the *six* figures side by side, the number is then divisible by 17.

(4) Similarly, if we take any number of three digits and double it, the figures placed side by side are exactly divisible by 167. Thus $123\times2=246$. Then 123246=167 M. Similarly $234\times2=468$. Thus 234468=167M. Nor need we confine the number to three digits, if we proceed on the principle given above. Thus $6789\times2=13578$. Therefore 6802578=167M, since 6789+13=6802, &c. The proof is similar to that of No. 3, and the principle is of wide application. *E.g.*, we may take any 5 figures and double them: the ten figures are divisible by 7. Thus

1862937258=7M.

(5) A general principle applicable to all numbers ending in 1, 3, 7, or 9 is as follows *:—

Take any number, say, 123456789=13R+1. Then

1123456789 or 12123456787,
2123456790 or 11123456786,
3123456791 or 10123456785,
&c. &c. &c. *ad infin.*

are all divisible by 13, without remainder.

Again, take 12349=7M+1.

Then

412349 or 312347,
812350 or 612346,
1212351 or 912345,
1612352 or 1212344,
&c. &c. *ad infin.*

are all exactly divisible by 7.

It will be readily perceived that the prefixes 4, 8, 12, 16, &c., also 3, 6, 9, 12, &c., are in arithmetical progression, as also the figures in the unit's place. The principle may be briefly stated in mathematical language as follows:—

$$np\ 10^m+\text{N(M)}+\text{n}=\text{N(R)}$$

where N and n are any integers; m the number of digits, p the prefix. The proof is not difficult. We know that 21, 301, 1001, 50001, 400001, 6000001, are divisible by 7. These prefixes 2, 3, 1, 5, 4, 6 follow the law $5p_n-7x=p_{n+1}$. Thus $5\times2-7=3$, &c.; and these values recur.

Thus if $\text{N}=n(\text{R})+1$ by hypothesis say $22=7(\text{R})+1$,

And we know that $pt^m+1=n(\text{R}_1)$ say $301=7(\text{R}_1)$,

Then $pt^m+\text{N}=n(\text{R}_2)$ or $3\cdot22=7(\text{R}_2)$,

Also $2pt^m+\text{N}+1=n(\text{R}_3)$ or $6\cdot23=7(\text{R}_3)$;

Also $3pt^m+\text{N}+2=n(\text{R}_4)$ or $9\cdot24=7(\text{R}_4)$.

Thus $npt^m+\text{N}+n-1=n(\text{R}_5)$,

or, since $\text{N}=n(\text{R})+1$,

$$np10^m+\text{N(R)}+n=\text{N(R)}.$$

Similarly for any prime number, say 19, the prefixes are 17, 15, 11, 3, 6, 12, 5, 10, 1, according to the law 19_r-2^n, and the values recur after $\frac{\text{N}-1}{2}$ values.

(6) It is not difficult to get the prefixes without actual trial or division, *e.g.*, What prefix will make the number 123456789 exactly divisible by 7?

Our formula for seven is $7x-3^nr$, *i.e.* $7\times4-3^3\times1=1$. Therefore 1123456789 is exactly divisible by 7.

Again, what prefix will make 123456789 exactly divisible by 13? Our formula for 13 is $13x-4^nr$, *i.e.* $13\times5-4^3\times1=1$. Therefore 1123456789 is also exactly divisible by 13. What prefix will make 1236 divisible by 19? Using our formula for 19, viz. $19x-2^nr$ we get $19-2^n=3$. Thus 31236, 61237, 91238, &c., &c., *ad infin.* are divisible by 19.

A few useful formulæ are—

$$2^n\,10^n-1=19\text{R}.$$
$$3^n\,10^{6m-n}-1=7\text{R}$$
$$4^n\,10^{6m+n}-1=13\text{R}.$$

(7) No. (5) *supra* enables us to obtain a convenient test for divisibility by any prime 75, *e.g.*:—

If 1234563=19M, then 123456=19M +13.

Therefore $123443=19\text{M}_1$ and $12344=19\text{M}_2+13$.

Then $12331=19\text{M}_3$ and $1233=19\text{M}_4+17$.

Thus $1216=19\text{M}_4$ and $121=19\text{M}_5+7$.

Therefore $114=19\text{M}_5$, &c.

The proof is simple. We have

$19\times9=171$	$19\times4=76$
$19\times8=152$	$19\times3=57$
$19\times7=133$	$19\times2=38$
$19\times6=114$	$19\times1=19$
$19\times5=95$	

If a number then end in any digit, say 3, and is also divisible by 19, then the other figures (however numerous) are of the Form 19M+13.

We see also from the table that if we multiply any of the digits by 17 and reject $19x$, we get the figures on the left.

A similar law applies to any of the primes. Hence the rules.

Let us test the number 123454 for 17.

Since $17\times3=51$ our multiplier for 17 is 5.

Say, then, $5\times4=20$, reject 17, leaving 3 and 3 from the next figure 5=2, thus $12342=17\text{M}_1$.

Proceeding, say $5\times2=10$ and subtract, leaving $1224=17\text{M}_2$.

Proceeding again, say $5\times4=20$, reject 17=3 and take 3 for $122=119=17\text{M}_3$.

Since the last result is true, therefore 123454 is a multiple by 17.

After a little practice the process can be gone through rapidly.

(8) It is generally known that we may square any number ending in 5 as follows:—Square 65. Here $5\times5=25$; $6\times7=42$. Thus $65^2=4225$. But it is not generally known, as can be easily proved mathematically, that the same principle applies to any two numbers whose tens' digits are alike, and whose units equal 10, *e.g.* multiply 86 by 84. Here $8\times9=72$; $4\times6=24$.

Therefore our result is 7224.

Again, multiply 177 by 173. Here $17\times18=306$; $7\times3=21$. Therefore the result is 30621.

Messrs. Murray have sent us a new and cheap edition of Darwin's "Voyage of the *Beagle*," the copyright in which appears now to have run out. Probably no book has done more to make naturalists than this simple narration of Darwin's earlier travels and observations.

* Multiples of these numbers only can have *all* the digits in the units place. Even numbers cannot nor those ending in 5.

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PHOTOGRAPHS OF NEBULÆ.

By A. C. RANYARD.

THE SPIRAL NEBULA IN URSA MAJOR.

81 Messier (G.C. 1949).

As shown on Mr. Isaac Roberts' photograph, this is a fine example of a spiral nebula, though up to the date of his photograph its spiral character had not been recognised. Dr. Copeland, using the Earl of Rosse's 3-foot reflector, describes it as very like the great nebula in Andromeda, though at the time of the observation (1871) the spiral character of the Andromeda nebula had not been recognised. With the 6-foot reflector in 1874, he found that the nebulosity extended about eight minutes of arc from the nucleus towards the north, and that the fainter portion was elongated in the north preceding and south following directions. He describes it as "extremely bright, very suddenly very much brighter in the middle to a nucleus." From Mr. Roberts' photograph it is evident that the plane of the spiral is inclined to us, so that the longer axis of the ellipse into which it projects is inclined in a north preceding and south following direction, as described by Dr. Copeland. The longer diameter of the ellipse is more than sixteen minutes, so that Dr. Copeland must have seen the parts of the nebula which Mr. Roberts' photograph shows to break up into spiral streams. Upon the stream lines of these faint spiral arms are a number of nuclei or possibly small stars, which reminds one of the arrangement of stars on the stream lines of the Andromeda and Canes Venatici nebulæ. There are no outlying smaller nebulæ, in the immediate neighbourhood of this spiral nebula as in the case of both the above-mentioned larger spirals. But the spiral structure of this nebula seems to be more regular. But about 42 minutes to the north of it lies a most remarkable elongated nebula known as 82 Messier (G. C. 1950). Towards its centre are two nuclei, each of which are double. The ray is divided in a transverse direction by two very marked dark channels. Ingall describes it in the *English Mechanic* for December 18, 1885, as having a twisted appearance like a "distaff of flax." The longer axis of this remarkable nebulous ray is inclined in a north preceding and south following direction. Huggins has found the spectra of both these nebulæ to be continuous, but deficient towards the red end.

THE SPIRAL NEBULA IN CANES VENATICI.

51 Messier (G.C. 3572).

This interesting nebula has been drawn by, amongst others, Sir John Herschel (see "Phil. Trans." for 1833), Lord Rosse ("Phil. Trans." 1850), Lassell ("Memoirs of the R.A.S.," vol. xxxv.), and by Vogel (see "Potsdam Observations," vol. iv.). Sir John Herschel's drawing only shows a partly split ring round a nebulous centre, with a small detached nebula to the north. Smaller instruments only show two unequal nebulæ nearly in contact. Sir John Herschel had an idea that there was an analogy between this nebula and the split ring of the Milky Way; but we now know that the nebula has a most complicated form. In addition to the spiral streams about the chief nucleus, there is a curved nebulous stream which joins the secondary nucleus towards the north, and an appearance as of a smaller spiral system about one of the stellar points on the preceding branch of the great spiral. The aggregation of stars or nebulous masses along the stream lines of nebulous matter is very marked. The smaller nebulous mass towards the north is cut off sharply on the following side. The nebulous stream which joins it to the great spiral comes up to its northern side; and on Mr. Roberts' negative there is an appearance of spiral structure even about this smaller nebula. Mr. Common obtained an excellent photograph of this nebula with his 3-foot reflector at Ealing about four years ago. The nebulous streams of this complicated structure are so marked that they were recognised by observers before the photographic era. The Earl of Rosse's drawing is perhaps the best of any made with his great telescope. It shows nebulous matter filling up the spaces between the great streams more than any other drawing. Mr. Lassell's drawing, and the one made by Dr. Vogel with the 27-inch refractor at Vienna, are also very good. Dr. Huggins finds the spectrum continuous.

THE DUMB-BELL NEBULA IN VULPECULA.

27 Messier (G.C. 4532).

The brighter parts of this nebula are very conspicuous, and in a small telescope resemble a dumb-bell in form, hence its popular name. It has been figured by a great many observers, amongst others Sir John Herschel, in the "Phil. Trans." for 1833; by the Earl of Rosse, in the "Phil. Trans." for 1844, 1850, and 1861; by Secchi, in the "Memorie dell' Osservatorio del Collegio Romano," 1852–55, plate iv.; by Smyth, in the "Speculum Hartwellianum," p. 290; by D'Arrest, in the "Instrumentum Magnum Æquatoreum;" by Trouvelot, in vol. vii. of the "Annals of the Harvard College Observatory;" and by Vogel, in vol. iv. of the "Publications of the Potsdam Observatory;" and by Ingall, in the *English Mechanic* for December 1874. Mr. Lassell gives a map of the stars in and about the nebula on a scale of 100 seconds to the inch in vol. xxxv. of the "Memoirs" of the R.A.S.

Mr. Roberts' photograph shows a brighter edge to the northern lobe of the dumb-bell, which is not shown in the drawings. The fainter nebulous matter, which forms the background on which the dumb-bell is seen, projects beyond the elliptic outline. It appears to be structureless, but the brighter region of the nebula breaks up into curdling masses of greater density. Several stars are seen projected on the nebula, one nearly centrally. The drawing which appears to me most nearly to represent the appearance seen on Mr. Roberts' negative is that by Father Secchi. According to Dr. Huggins, the spectrum of this nebula consists simply of one bright line.

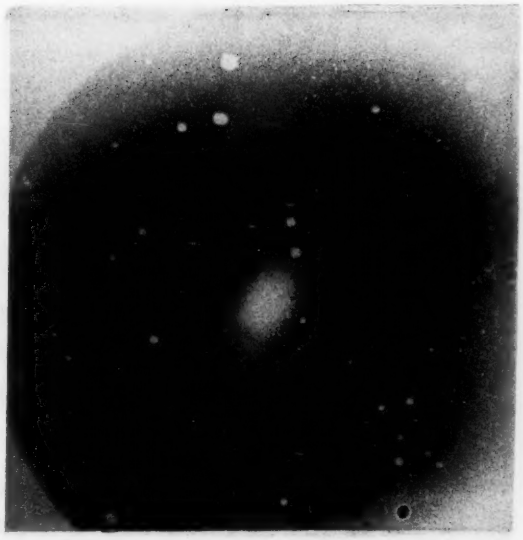
STAR-BORN METEORS.

By the late RICHARD A. PROCTOR.

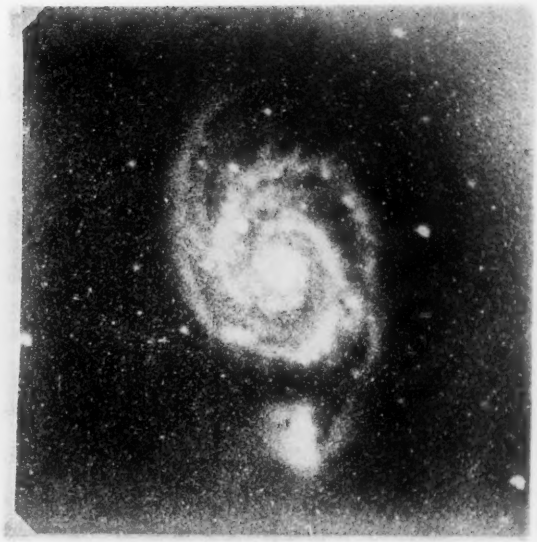
(*Continued from p.* 16.)

MUCH was the position, on the one hand of meteoric astronomy, and on the other of the various theoretical conclusions which were either demonstrably deducible from discovered facts, or seemed more or less probable as viewed in their light. Putting all theory aside, so much as *this* was certain, and is certain,—among the meteoric streams encountered by the earth each year, some are undoubtedly travelling in elliptical orbits around the sun; and among these some are as certainly following in the tracks of known comets. Moreover, among all the paths thus *determined*, none are of such extent that the velocities of the meteors where they cross the earth's track exceed enormously the velocity of the earth in her orbit.

This being so, students of meteoric astronomy heard, with some surprise, an announcement by Mr. Denning four or five years ago, that he had discovered certain systems of meteors which could not possibly be explained by anything thus far demonstrated respecting these bodies. It was not in such terms, indeed, that he announced his discovery, but that was undoubtedly what it amounted to. He stated that

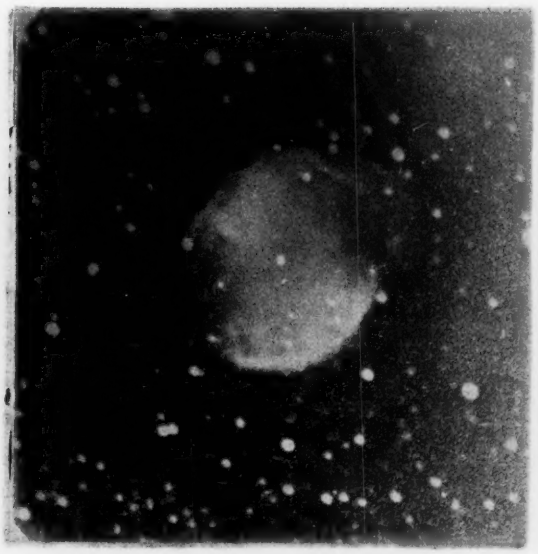


81. Messier, IX. h. 47 m. 12s., N., 69° 41′ (1900). Spiral nebula in Ursa Major, enlarged about 5 diameters from a negative by Mr. ISAAC ROBERTS, taken 31st March, 1889, with an exposure of 4 hours.



51. Messier, R.A. XIII h. 25m. 27s., N., 47° 42′ (1900). Spiral nebula in Canes Venatici, enlarged about 8 diameters from a negative by Mr. ISAAC ROBERTS, taken 21st April, 1889, exposed for 4 hours.

81 & 82. Messier, enlarged about $1\frac{3}{4}$ diameters from a negative by Mr. ISAAC ROBERTS.



27. Messier, R.A. XIX h. 55m. 3s., N., 22° 27′ (1900). The Dumb Bell nebula in Vulpecula, enlarged about 8 diameters from a negative by Mr. ISAAC ROBERTS, taken 29th April, 1889, with an exposure of 4 hours.

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some meteor flights radiate from the same small region or radiant point for several months in succession! If we consider what this means, we shall see at once how utterly irreconcilable it is with what had been discovered respecting other meteor systems. In the course of three months the direction of the earth's path changes through a right angle. Thus, while on December 20 the earth is travelling along at the rate of 18¾ miles per second towards a point between the stars Eta and Beta of the constellation Virgo (a little south of such a point), three months later the earth's course is directed almost exactly towards the star Mu of the constellation Sagittarius—three signs, or a quarter of the full circuit of the heavens, away from the first-named point.* Now the earth's motion in her orbit being thus rapid, had always been taken into account in inferring the real direction of the motion of meteors as they entered her atmosphere, from the course on which they appeared to travel. Although a meteor travelling on a very eccentric orbit—one of the November or August meteors, for example—might have a velocity of 27 miles per second on its own orbit, yet the effect of such a motion as the earth has, about five-sevenths of the velocity of the meteors themselves, could not but largely modify the apparent direction of their tracks as they entered our air. In point of fact, just as when we are rushing swiftly along, in an open carriage, through a heavy rain-shower, the rain-drops seem to meet us more fully than they actually do, and we lower an umbrella in front as if the rain were driving nearly horizontally in our faces, so, whatever the real direction of a flight of meteors, it always seems to come from a radiant nearer by many degrees to the point towards which the earth is travelling than is actually the case. Thus the November shower, which really crosses the earth's track at a considerable angle, in a direction opposite to that in which the earth is travelling—the meteors moving with velocities of about 26 miles per second—*appears*, in consequence of the earth's swift motion, to come from a point in the constellation of the Lion not very far from the point towards which the earth is advancing, and the meteors rush into the air of the swiftly advancing earth at an apparent rate of fully 44 miles per second. Now, if we suppose our earth's course suddenly changed through a right angle, when she is in the midst of this flight of meteors, it is clear that the apparent velocity and direction of their entry into our atmosphere would be largely altered—the apparent velocity would no longer be increased by a rapid motion of the earth *towards* the advancing meteors, and the radiant would no longer be shifted nearer to the point of the star-sphere, towards which, *before the change*, the earth had been advancing. The new radiant point for the star-shower would lie many degrees from that point in the Lion (in the midst of the group called the Sickle in Leo) from which the November meteors appear to radiate. So with the August meteors, and with any system known to be travelling on a closed orbit, no matter how enormous its extent, for no meteor so travelling can cross our earth's track with a greater velocity than 27 miles per second, and the earth's velocity of 18¾ miles per second bears so great a proportion to such meteoric velocity that every change in her direction must in large degree affect the apparent direction of meteoric motion.† So that if a meteor-stream were so wide that the earth took several days in traversing it, the radiant point of the meteoric paths would shift quite largely among the stars. This is no mere theory, but absolutely certain,—indeed a very simple deduction from obvious geometrical relations. Just as certainly as a gale seems to change its direction when a steamer exposed to it changes her course through any considerable angle, so certainly would the apparent direction of meteoric motion seem to change as the earth changed her course, if she were several days in passing through the stream. And, as a matter of fact, in the few cases where the earth does occupy several days in passing through a meteoric system, such a change of the radiant point of the system is observed to take place. Thus, the August meteors, though their time of greatest frequency is about August 10–11, are visible from July 25, when the first few stragglers appear, to August 20, when the last are seen. During this time the radiant of the system changes about 42 degrees in position on the celestial sphere, or nearly half the distance which separates the point overhead from the horizon.

What, then, are we to understand from the persistence of the radiant point of a meteor-system during three or four months? If actually demonstrated, such persistence would show, beyond all possibility of doubt or question, that the earth's velocity of 18¾ miles per second is so small, compared with the velocities of the meteors thus seen, as not appreciably to affect their apparent direction. Just as swift motion in a carriage appreciably affects the direction in which rain seems to fall, but would not appreciably affect the direction in which bullets fired at the carriage from a battery would seem to strike, so the rush of the earth at the rate of 18¾ miles per second must markedly affect the apparent motion of meteors travelling on closed orbits round the sun (seeing that these cannot travel more swiftly than 27 miles per second); but this motion of the earth would not affect in any recognisable degree the apparent motion of meteors travelling with velocities of several hundred miles per second athwart the earth's track. But then, to cross the earth's track with such velocities, meteors must be travelling on other than closed or elliptic orbits. In other words, they must be travelling on hyperbolic paths, coming to our system from athwart the interstellar depths with velocities greatly exceeding those the sun can communicate by his attractive might, or than he can control in bodies at the earth's distance, and so passing away on another interstellar journey to visit some other star system; flitting thus from sun to sun, but not to be retained within the domain of any.

Now it appeared to me, and also to all who had mastered and understood the theory of meteoric motions as hitherto observed and demonstrated, that the inference thus certainly deducible from Mr. Denning's discovery, if real, was so utterly improbable as to render his discovery exceedingly doubtful. I, for my own part, regarded it as far more likely that Mr. Denning had been deceived by accidental coincidences than that he had really observed that which would have had so marvellous, one may say so astounding, an interpretation. I had often spoken in my lectures of comets and meteors flitting from star to star, and had in several essays mentioned such bodies as undoubtedly existing. In my essay on Gravitation in "The Expanse of Heaven" I had calculated the time which meteoric bodies

* See my "Seasons Pictured," from the zodiacal maps in which the point towards or from which the earth is travelling at any moment can be readily determined.

† To show this, draw a line 27 inches long, and at right angles to it from one end a line 18¾ inches long (the real proportion is that of the diagonal to the side of a square), and around the point where the two lines meet describe a circle having the shorter line for radius—then lines from the other end of the longer line to different parts of the circumference of this circle vary as much as the apparent paths of meteors would seem to vary if the earth's motion were varied through all possible directions (its velocity remaining unchanged), while within a meteor-stream, travelling at the rate of 27 miles per second. The full amount of apparent change of direction would be no small angle, but one whole right angle!

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would take to travel from the nearest star to our own system; while in my essay in the *North American Review* on the Origin of Comets and Meteors I had spoken of many meteoric bodies as certainly reaching our earth from the interstellar depths, and primarily from the interiors of the fixed stars. But the idea had not presented itself to my mind that streams of meteors from remote suns could retain after their journeys across the interstellar depths velocities of many hundred miles per second, or that such streams could at our distance from even the nearest stars retain so much of the character of streams that the passage of the earth through any such system should indicate the position of their radiant point. Still less did it seem likely to me that such streams should remain recognisable by meteors observable not only for several successive months in one year, but during several successive years.

Thus, like Professor Alex. Herschel, Mr. Greg, and others, I regarded Mr. Denning's observations as insufficient to establish so marvellous a result as they would unquestionably demonstrate if accepted. I did not reject them; but it appeared to me that they should not be accepted until overwhelming evidence had been obtained in their favour. Thus I waited, though fully recognising the validity of what Humboldt said in his "Physical Description of the Heavens," speaking, more than a quarter of a century ago, on this very subject:—"The progress of our knowledge, respecting igneous meteors," he said, "will be the more rapid the more impartially facts are separated from opinions, so that while carefully sifting or testing all particular facts on the one hand, we may not, on the other, fall into the error of rejecting, as bad or uncertain observations, whatever results we are not yet able to explain." "It appears to me most important," he went on, "to separate physical relations from those geometrical and numerical relations which admit, generally speaking, of more certain and assured investigation." Only it is to be noticed that the trouble with Mr. Denning's observations was not at that time that they were not easy to explain. Mr. Denning himself appears still to imagine that this is the difficulty. The real source of perplexity lay, and the real interest of his discoveries lies, in this, that they can bear but one explanation, and that that explanation is so singular and so interesting.

There is, as I pointed out to Mr. Denning four years ago, but one explanation of a meteor-stream having an unvarying radiant for several months in succession—viz. this, that the component meteors are travelling on parallel paths through the interstellar depths, and cross our solar system with such velocities, that during their passage athwart the domain of the sun their paths are hardly deflected at all, at least until they are far within our earth's distance from the sun. Thus the earth's atmosphere receives them on nearly parallel paths; though perhaps such as fall on Venus and on Mercury may have had their directions appreciably altered, because of the more energetic solar attraction to which they have been exposed. For the same reason that the influence of the sun at the earth's distance does not affect the real course of these swiftly-travelling meteors, the varying direction of the earth's motion does not influence their apparent direction; a velocity of $18\frac{3}{4}$ miles per second is as nothing compared with the swift rush of those meteors through space.

It was because of the unlikely nature of this—the only possible explanation of Mr. Denning's discovery—that until the discovery should be confirmed by sufficient evidence I regarded it as doubtful. As a problem of probabilities, the unlikelihood of the conclusion certainly deducible if the observations were trustworthy, overbalanced then the evidence—strong though it seemed—in favour of the facts supposed to have been observed.

Observations have now, however, continued long enough to make further doubt respecting their *general* validity unreasonable, and the balance of probabilities is so far turned the other way that we may begin to inquire *in what degree* the observations may be accepted. Carefully weighing the evidence gathered by Mr. Denning himself, and combining it with that which Messrs. Greg, A. Herschel, Konkoly, and others have obtained, the probability of error, or that merely accidental coincidence is in question, becomes so small, that even the seemingly immense unlikelihood of the conclusion to which the observations unmistakably point, disappears. We have to accept the observations, and with them the inferences deducible from them. We learn that: *Besides the meteors which form systems travelling on closed paths around the sun, besides those meteors which had been recognised as coming from interstellar space with velocities not greatly exceeding those which our sun can communicate to bodies approaching him from a distance, and besides those less certainly recognised which have been regarded as ejected from the earth herself in past ages, there are some which reach our solar system with what may be described as extra-planetary velocities—with velocities so great that the earth's velocity in her orbit is by comparison small.*

Only, it must be remarked that Mr. Denning's observations cannot be accepted as interpreted by him. (I am not referring to any explanation he offers, for he offers none—seeming, indeed, to be of those who lose interest in observations, even their own—when apparently pointing to anything so unworthy of esteem as new truths.) He speaks of his "radiants" as *stationary*, which is impossible. When pushed, he claims to determine them within a couple of degrees. It is not only altogether unlikely that they change so little as this, it is absolutely impossible that Mr. Denning, or even Mr. Greg or Professor Herschel, could determine the radiant point of meteors, even during a one-night shower, within five or six degrees. If we admit that some radiants seem to change so little, in several months, as to indicate velocities up to one hundred miles a second, that will correspond with Mr. Denning's observations — as reasonably interpreted—and be quite remarkable enough even then.

Schiaparelli's vague guess respecting the origin of meteors (oddly described by Professor Young as "the received theory") fails utterly in the presence of this apparently recognised fact: my own suggestion on the same problem, based as it was on strong evidence, both positive and negative, not only does not fail, but actually makes the very result which seems so amazing antecedently probable. Let us consider:—

In my theory appeared three classes of bodies as parents of meteor-systems:—*First*, the earth and her fellow terrestrial planets, as the parents—when in the sunlike stage—of minor families of meteors crossing severally the tracks of their generating orbs; *secondly*, the giant planets, as the parents when in the sunlike stage, possibly even now, of meteor-systems travelling around the sun, but crossing the orbits of the giant planets from which they respectively came; *thirdly*, our sun and his fellow suns, as the parents of families of meteors which only pay occasional visits to other solar systems than those from whose ruling centre they originally proceeded. Is there no higher order of bodies which might have generated meteors travelling with the greater velocities now recognised? Undoubtedly there is a class of bodies which not only might have generated such velocities, but, if my theory of the origin of meteors is sound, might be expected to have ejected meteors with velocities of those high orders. There are the giant suns, like Sirius and his fellows, so enormously surpassing our own sun, and those among the stars which must be regarded as his fellows,

as to differ not merely in degree but in kind (just as suns differ from giant planets, these from our earth and her fellow-planets of the—so-called—terrestrial order, these from asteroids, and asteroids from meteors). Of six hundred stars examined by Secchi, one-half showed the spectrum characteristic of the giant suns, the spectrum belonging to Sirius (*known* to be a giant sun) and to all the bluish-white stars—a spectrum characterised by the great strength and breadth of the hydrogen lines. As Sirius gives out 200 times as much light as our sun, he probably has a surface 200 times as large, a diameter 14 times as large, and a volume 3,000 times as large. Assigning to him a volume only 1,000 times as large, we must regard him as belonging to a higher order among suns: and probably all the orbs which have a similar spectrum belong to the same order.

Now, if our sun can eject bodies with a velocity of 500 miles per second, as he has been observed to do, which would imply the power of ejecting bodies with such velocity that not only would they pass for ever away from him, but they would never have their velocities reduced by his retarding action below 22 miles per second, we may fairly expect that among meteors coming to the solar system from our sun's fellow-stars, would be some travelling with velocities of 20 or 30 miles per second, in addition to the velocities acquired under the sun's attractive influence while they were drawing near to him. (These added velocities, I may remark in passing, would be considerably less than those which the sun can impart to bodies approaching him under his own attractive influence only.) But among bodies ejected from the giant suns would certainly be many travelling with much greater velocities than 20 or 30 miles per second—probably many with velocities of more than 100 miles per second, even after they have passed into interstellar space. Such bodies, travelling in flights, would account perfectly for the meteor systems with persistent radiant points detected by Mr. Denning.

In other words, the conclusions which, on any other theory of the origin of meteors and comets than that which I have advanced, appeared so improbable that even the strongest evidence seemed for awhile insufficient to establish them, are found to follow so naturally from the processes which my theory indicated, that we might almost have expected them to be established by just such evidence as Mr. Denning has obtained. Only, of course, his description of these radiants as stationary, as well as his opinion as to the close approach to the determination of the radiant which he supposes himself able to make, must both be rejected.

It is interesting to note, in conclusion, that, with velocities averaging 100 miles per second, meteors would not require many thousands of years to traverse such distances as separate star from star (that is, sun from sun), instead of the period of several millions of years required for these journeys as heretofore viewed. But thousands of years are as mere seconds in cosmical astronomical time. So that star-born meteors of the orders recently recognised might fairly be described as *flitting from sun to sun.*

Letters.

The Editor does not hold himself responsible for the opinions or statements of correspondents.]

EXTRACT FROM A LETTER FROM PROFESSOR W. H. PICKERING.

. . . . I was much interested in your article on the Orion nebula, as I am preparing an article on the subject myself. I think no one can examine the photograph carefully without being struck by the similarity to some of the coronal forms. I was rather disappointed in Mr. Roberts' photographs. In detail they may be slightly better than the Harvard pictures, as his focal length is more than twice ours. But in extent they certainly do not excel, and I scarcely think equal, one of ours taken a year ago last February, with an exposure of only 90 minutes. You will find a lantern slide copy in the rooms of the Royal Astronomical Society. I notice in your article you speak of the nebula to the north of the great nebula. Our negatives show them to be connected by a nebulous mass of considerable complexity. In fact the whole sword handle is simply one great nebulous mass. I hope to have my article ready for distribution in a few weeks. . . . .

May 27, 1889. W. H. PICKERING.

EXTRACT FROM A LETTER FROM PROFESSOR E. S. HOLDEN.

. . . . I am much interested in the resemblances which you point out in Mr. Roberts' wonderful photographs of the Orion nebula and the coronal forms. Mr. Roberts was kind enough to send us prints of his Andromeda nebula, but I have not seen any copy till now of the Orion nebula. It is most interesting. With the original negatives before you, you are in a position to judge of the analogies to groups of synclinal structure in the corona and in the nebula. I have looked over my own notes of the nebula (central parts only), and find nothing of importance which can strengthen your argument except perhaps the existence of cometic tails to the stars Bond 685, 708, 741, the three s.p. the trapezium. These *look* like the polar rays of the corona. . . . We expect to send a (photographic) expedition from here to South America to observe the December eclipse. I shall be very glad of any information which you can give us as to the best stations (healthiest, most convenient of access, most likely to be clear), and for any notice of the plans of other parties, so that we may co-operate with them. . . . E. S. HOLDEN.

Lick Observatory: May 28, 1889.

To the Editor of KNOWLEDGE.

SIR,—Your article on lightning photographs has interested me greatly. Among the many ingenious suggestions which it contains, what appears to me to be a very obvious one as to the cause of the dark flash has been omitted. We know from common observation that there is blue lightning and pink lightning, and we know that the two colours act very differently on the photographic plate. I have before me a photograph of a young lady in a blue dress, wearing a red rose. The blue dress has come out absolutely white, and the pinkish rose seems nearly black upon it. May there not be the same effect with lightning?—I am, Sir, yours obediently, G. H. CLARKE.

[The so-called black flash is absolutely darker than the background of sky on which it appears. The red rose or pink lightning would have a slight effect in darkening the plate, though a slower one than the blue dress or the blue lightning. We have to account for something which cuts down the light of the background on which it is seen, and not merely for a difference of rate of light action.—EDITOR.]

THE DARK FLASH.

To the Editor of KNOWLEDGE.

SIR,—With the June part of KNOWLEDGE there appeared facsimiles of a considerable number of lightning-flashes, many of which were very curious, and nearly all strikingly beautiful.

XUM

In plate No. 4, forming part of the frontispiece, was shown the well-known but puzzling appearance to which the rather paradoxical title of "The Dark Flash" has been given. This, it will be remembered, is a black line, similar in character to ordinary lightning-flashes, and in this case especially like those on the same plate. It has been suggested that this dark line on the plate may result, through some photographic complication, from an actual and immediate bright flash—that is, that the black line of the plate may really be a picture of a *bright* line. Professor Stokes, however, as explained in the text, is of the opinion that the dead flash is really the dark line which it appears on the photograph, and that it follows in the track of an antecedent bright flash. Steps have been proposed by which direct evidence upon this point may perhaps be obtained.

In the meantime it has been suggested (as was also set forth in KNOWLEDGE last month) that the dark line is due to absorption of light by a column of dark-coloured—to wit, reddish-yellow—gases, produced by the direct union, under the influence of electricity, of the oxygen and nitrogen in the air. It is well known to chemists that if the sparks of an induction coil be passed continuously through a vessel containing air, yellowish fumes will presently form, consisting of nitrogen trioxide (N_2O_3) and nitrogen peroxide (NO_2); and there is no doubt that the same thing occurs when a thunderstorm takes place, these gases being found dissolved in rain-water collected after thunder. Whether they are formed indirectly or directly there is not, so far as I am aware, any evidence to show. It may well be that nitrogen dioxide (N_2O_2) is first formed, and that this colourless gas subsequently absorbs additional oxygen, thus forming the familiar red fumes of the higher oxides. However this may be, it does not at present affect the question in hand, and the point need not have been raised, except that I can imagine it coming up later on, when further steps have been taken experimentally to ascertain the cause of the dark flash.

Now this experiment, though not often performed on the lecture-table, is fully set forth in all the text-books. But there is nothing, so far as I can ascertain, to show that, even in the undisturbed air of a laboratory gas-holder, the fumes exhibit any tendency to follow the line of the electric sparks. I have never been able to see that they do so, and indeed it would be a remarkable deviation from the usual behaviour of free gases if they did. Gases invariably tend to diffuse themselves, and this property would surely prevent the nitrous and nitric fumes from forming, even for a very short space of time, a line or column as narrow and as sharply defined as the dark flash is clearly shown to be. It is noteworthy that on this hypothesis the photograph of the dark flash must be impressed upon the plate some seconds at least after the flash which it belongs to.

As an alternative explanation it has been suggested that the dark track shows the smoke of burnt dust floating in the air and preserving the shape of the flash which burned it up. This is ingenious; and the dark flash in photographs certainly looks more like a truly black line than a reddish-yellow one, which would hardly be expected to produce so decided an effect. On the other hand, however, it must be remembered that the dust particles are very minute indeed; being, in fact, often invisible even with high microscope powers. Even if any smoke at all be produced, it must therefore be very small in amount, and fine in texture, which renders doubtful the possibility of photographing it. Moreover, it is probable that the extreme heat of the flash would be capable of entirely volatilising such infinitesimal matter, which would disappear instantaneously, and, like Prospero's insubstantial pageant,

"Leave not a wrack behind."

I believe, nevertheless, that the true explanation of this phenomenon is to be found in connection with the floating matter of the air. Before coming directly to the point, however, it will be necessary to work back a little.

We have all observed the stream of intangible dust which shows itself in the track of any sharply-defined sunbeam, giving the latter an almost solid appearance. It is not generally known that the path of the ray could not be traced at all if this floating matter were absent. It is the fact, however, that if the floating matter of the air be by special means removed from a room, or, more conveniently, from a glass tube, rays of light, though still passing uninterruptedly through the vacant space, can no longer be followed by the eye in their course.* Now, if from a certain portion of a beam of light the suspended solid matter of the air be artificially abstracted, that portion of the beam will appear to be traversed by a distinct black line. This circumstance was first fully explained by Professor Tyndall in his essays on "The Floating Matter of the Air."†

He writes:—"In a cylindrical beam which strongly illuminated the dust of the laboratory I placed an ignited spirit-lamp. Mingling with the flame and round its rim were seen curious wreaths of darkness, resembling an intensely black smoke. On placing the flame at some distance below the beam the same dark masses stormed upwards. They were blacker than the blackest smoke. . . ." At first he was inclined to think that the blue flame of alcohol did not, after all, represent complete combustion. "But is the blackness smoke?" he goes on to ask. "This question presented itself in a moment, and was thus answered:—A red-hot poker was placed under the beam; from it the black wreaths also ascended. . . . Smoke was therefore out of the question. What, then, was the blackness? It was simply that of stellar space—that is to say, the blackness resulting from the absence from the track of the beam of all matter competent to scatter its light. When the flame was placed below the beam, the floating matter was destroyed *in situ*, and the air, free from this matter, rose into the beam"—being forced up by the heat of the flame. A subsequent experiment in the same field bears directly on the subject of this paper. Professor Tyndall tried the effect of stretching a platinum wire, afterwards heated to redness by a current of electricity, just under the path of the beam from a powerful light. He writes—"A stream of air rose from it, which, when looked at edgeways, appeared darker and *sharper* than the blackest lines of Fraunhofer in the purified spectrum. Right and left of this dark black band the floating matter rose upwards, bounding definitely the non-luminous stream of air."‡ Now is it not evident from this that the dark flash—so called—may well be due to the destruction of the floating dust by the ordinary flash, and the consequent inability of its track to reflect the light of a subsequent flash? The extreme sharpness of the line agrees well with Tyndall's observations, and the intensely black appearance of the smoke-effects which he mentions will account for the ease with which the dead flash is photographed, in a way which neither the nitric fume explanation nor the dust-smoke explanation will do. It is fair to remark, however, that Tyndall does not speak of the appearance of the beam *after* the platinum wire was removed;

* The electric beam is well known to bacteriologists as a test of floating matter far surpassing in delicacy the most powerful magnifying instruments. The air of a chamber is known to be completely sterilised only when it fails to reveal the track of a ray of light. To vessels in this condition Professor Tyndall applies the term "optically empty."

† *Longmans* (1881), p. 5.

‡ *Ibid.*, p. 6. The italics are mine.—T. B. R.

but any one who will take the trouble to make the experiment with a red-hot poker will be able to see that the effect persists for quite an appreciable time—certainly long enough for a flash of lightning to appear.

It should not be difficult to directly verify the theory, here advanced for (I believe) the first time. Let some one, who has the requisite appliances, so arrange the beam from an oxyhydrogen or arc lantern, that a series of sparks from a Wimshurst machine may play athwart it in a suitable atmosphere. The track left by these sparks should, if there be anything in the theory, be readily photographed.—Yours faithfully,

1 Roehampton Street, S.W. T. B. RUSSELL.

[The objection to Mr. Russell's theory which presents itself, is that the dark flash must be seen through a great thickness of dust-laden illuminated air, and also on a background of dust-laden air equally lit up, and a small thickness of dustless air in the region of the dark flash would make no appreciable difference in the amount of light received from the direction of the flash.—EDITOR.]

THE VANILLA.

OF the many admirers of vanilla, and of vanilla-flavoured confectionery, but few know that it is produced from a species of orchid. This plant seems to require very little soil for its nourishment, and it generally attaches itself by means of its little aerial rootlets to walls, trees, and other suitable objects. It has a somewhat long and fleshy stem, and the leaves are alternate, oval, and lanceolate (shaped like a lance). The flower is of a greenish white, and forms axillary spikes. The fruit, which is a pod, when full grown measures from ten to twelve inches, and is about half an inch in diameter. The commercial vanilla (from the Spanish, *vainilla*, diminutive of *vaina*, a pod) is generally produced from the plant *Vanilla planifolia* (Andrews), a native of Eastern Mexico. It is also extensively cultivated in Réunion, the Seychelles, and Java, but the Mexican vanilla is thought to be the best. The quality of a vanilla pod can always be determined by the presence or the non-presence of a crystalline efflorescence called *givre*, and also by the colour of the pod, which in the best varieties is of a dark chocolate brown. But it is the crystalline efflorescence which contains the substance to which the fragrance of vanilla is due. This substance is called *vanillin*, and is chemically known by the formula $C_8H_8O_3$. The pods contain also vanilla acid, oily matter, soft resin, sugar, gum, and oxalate of lime. The choleraic effects that sometimes occur through eating ices flavoured with vanilla may not be due to the vanilla, but to putrefactive changes in the milk; but it is known that the vanilla plantations are subject to the attack of a little pest known as *Bacterium putredinis*, and it is quite likely that the poisonous effects from ice-eating can be accounted for by the presence of some microscopic fungi in the vanilla.

In the plantations the vanilla plant is generally fertilised by hand, but, like other orchids, there is no doubt its fertilisation is promoted by insects when in its natural state. The wild plant yields a smaller fruit, and is distinguished in Mexico as *Baynilla cimarona*, while the cultivated vanilla they call *Baynilla corriente*. A. J. F.

REFRACTION OF MAGNETIC RADIATION.

As the readers of KNOWLEDGE are aware, Dr. Hertz has made us familiar with the phenomena of reflection and interference of ether waves due to electro-magnetic radiation. By means of a prism of pitch, he has more recently obtained an experimental proof of their obedience to the laws of refraction. Professor Oliver Lodge has now gone a step further. In a paper read before the Physical Society he described a series of experiments he had carried out in conjunction with Dr. J. L. Howard, in which they had employed a pair of plano-convex hemi-cylindrical lenses, made of the best commercial pitch. With these lenses they performed such experiments as would be made with a beam of light and similar lenses of glass. We may mention that the lenses were 85 centimetres high, 90 centimetres broad, and 21 centimetres thick. The weight of them being about 3 cwt. each. Dr. Lodge found that the results obtained with them were throughout in complete agreement with those of Professor Hertz.

The *Magic Lantern Journal* is the title of a new monthly which has been sent us. The existence of such a periodical may be taken as evidence that there is some one who believes there is a large class interested in the illustration of lectures. We greatly welcome the growing tendency to illustrate lectures by photographs thrown on the screen. If the photographs are untouched, such illustrations bring the audience more directly into contact with the thing to be studied than any hand-drawn pictures.

The total length of the submarine cables at present in use is given by an Austrian paper at 113,031 miles. Of this length 102,531 miles belong to various companies, and 10,500 are Government property.—*Electrical Review.*

THE FACE OF THE SKY FOR JULY.

BY HERBERT SADLER, F.R.A.S.

THERE is still a marked absence of spots of any size on the sun's surface. During the first three weeks of July there will be no real night in any part of the British Islands. Minima of the Algol-type variable δ Libræ (cf. "Face of the Sky" for April) occur on the 1st at 8h. 24m. P.M. on the 8th at 7h. 58m. P.M., on the 14th at 7h. 32m. P.M. on the 22nd at 7h. 6m. P.M., and on the 28th at 6h. 40m. P.M. Mercury is a morning star throughout July, and is well placed for observation during the second and third weeks of the month. He is at his greatest western elongation on the 12th (20° 37′ W.), when he rises at 2h. 40m. A.M. or 1h. 20m. before sunrise, with a northern declination of 20¾°, He appears then as a half moon with an apparent diameter of 7½″. On the 20th he rises at 2h. 43m. A.M., or 1h. 26m. before the sun. At 3h. A.M., on the morning of the 9th, Mercury will be about 18′ *n.p.* the 4½ magnitude star χ′ Orionis. During this month he passes from Orion through Gemini into Cancer. Venus is a morning star, and is at her greatest elongation (45½°) west on the morning of the 10th, when she appears as a half-moon with an apparent diameter of 24″. She rises on the 1st of the month at 1h. 28m. A.M., having an apparent diameter of 25½″, and a northern declination of 15¾°. On the 31st she rises at 1h. 0m. A.M., having then an apparent diameter of 19″ and a northern declination of 20¾°. Throughout July she is in the constellation Taurus; passing through the northern portion of the Hyades about the middle of the month. On the morning of the 13th Venus will be about 40′ *n.p.* the 4th magnitude star δ Tauri, the planet and star forming a

pretty naked-eye pair; on the morning of the 14th she will be about 25′ *n.f.* the 4½ magnitude star 68 Tauri, and on the morning of the 23rd she will be 30′ north of the 5½ magnitude star 106 Tauri, and 8′ *n.p.* the 6½ magnitude star 107 Tauri. Mars is invisible. Jupiter, owing to his great southern declination, is very badly placed for the observer. He rises on the 1st at 7h. 35m. P.M., having a southern declination of 23¼°, and an apparent diameter of 46″, and on the last day of the month at 5h. 25m. P.M., his southern declination having increased by 6′, and his diameter decreased to 44½″. He describes a short retrograde path in Sagittarius, and on the night of the 13th will be 24′ south of and a little *p* the 5½ magnitude star Piazzi xvii. 386. He will be not far from the moon on the evening of the 11th. The following phenomena of the satellites occur between the times of the planet's being 8° above the horizon and the sun's being 8° below, and midnight G.M.T. on the days named. At 10h. 22m. P.M. on the 6th, an occultation (disappearance) of the first satellite. On the 7th at 9h. 45m. P.M. an egress from transit of the first satellite, and at 10h. 5m. P.M. the egress of its shadow. At 11h. 37m. P.M. on the 9th an occultation (disappearance) of the second satellite. At 9h. 20m. P.M. on the 11th an egress from transit of the second satellite, and at 10h. 10m. P.M. the egress of its shadow. At 9h. 42m. P.M. on the 14th a transit ingress of the shadow of the first satellite (the satellite itself being already on the disc of the planet), at 11h. 30m. P.M. the egress from transit of the satellite itself, and at 11h. 59m. P.M. the egress of the shadow. On the 15th at 9h. 17m. 28s. P.M. a reappearance from eclipse of the first satellite. At 11h. 30m. P.M. on the 17th an occultation (disappearance) of the third satellite. At 10h. 6m. P.M. on the 18th a transit ingress of the shadow of the second satellite, and at 11h. 37m. P.M. an egress of the satellite itself. On the 21st at 10h. 59m. P.M. a transit ingress of the first satellite, and at 11h. 37m. P.M. a transit ingress of its shadow. On the 22nd at 11h. 12m. 11s. a reappearance from eclipse of the first satellite. At 11h. 30m. P.M. on the 24th a transit ingress of the shadow of the fourth satellite. At 11h. 15m. P.M. on the 25th a transit ingress of the second satellite. At 9h. 29m. 56s. on the 27th a reappearance from eclipse of the second satellite. At 10h. 30m. P.M. on the 28th an egress from transit of the shadow of the third satellite. On the 29th at 10h. 4m. P.M. an occultation (disappearance) of the first satellite. At 9h. 28m. P.M. on the 30th an egress from transit of the first satellite, and at 10h. 18m. P.M. an egress of its shadow. Saturn may be caught low down on the western horizon during the first fortnight of the month; after that he will be too near the sun to be visible. On the first he sets at 10h. 16m. P.M., and on the 14th at 9h. 29m. P.M. He describes a short direct path in Leo, but does not approach any naked-eye star very closely. Uranus is in Virgo, and sets on the 1st at 11h. 59m. P.M., and on the 31st at 10h. 1m. P.M. He describes a short path to the S.E. between θ Virginis and Spica. Neptune is invisible. Shooting stars are fairly numerous in July, though the twilight interferes with observation. A well-marked shower radiates from near δ Aquarii; the maximum being on the 28th. The radiant point is in 22h. 40m. −13°. The moon enters her first quarter at 5h. 59m. A.M. on the morning of the 6th, is full at 9h. 2m. P.M. on the evening of the 12th, enters her last quarter at 7h. 45m. P.M. on the afternoon of the 19th, and is new at midnight on the 27th. There will be a partial eclipse of the moon on the evening of the 12th, which will be partly visible at Greenwich, slightly less than half the lunar disc being observed at the greatest phase. The first contact with the shadow takes place at 7h. 43·1m. P.M., at an angle of 39° from the north point of the moon's limit towards the east, the moon rising at Greenwich at 8h. 14m. The middle of the eclipse is at 8h. 54m. P.M., when 0·48 of the lunar surface will be obscured. The last contact with the umbra takes place at 10h. 4·9m., at an angle of 45° from the north point towards the west. These angles are for direct image. The last contact with the penumbra takes place at 11h. 12½m. P.M. On the 6th at 8h. 5m. P.M. the 6th magnitude star 80 Virginis will disappear at an angle of 56° from the vertex, and reappear at an angle of 290° at 9h. 12m. P.M. The 6th magnitude star o^2 Libræ will disappear at 7h. 48m. P.M. on the 8th at an angle of 75° from the vertex, and reappear at 8h. 59m. P.M. at an angle of 240° from the vertex. The 6th magnitude star B.A.C. 6343 will disappear at 11h. 43m. P.M. on the 11th, at an angle of 137° from the vertex, and reappear at 0h. 36m. A.M. on the 12th at an angle of 239° from the vertex. At 1h. 16m. A.M. on the 12th the 6th magnitude star 26 Sagittarii will disappear at an angle of 77° from the vertex, and reappear at 2h. 11m. A.M., at an angle of 333° from the vertex. At 7h. 22m. P.M. on the same day the 6½ magnitude (it is really fainter) star B.A.C. 6699 will disappear at an angle of 47° from the vertex, but the star is below the horizon at the time, the moon not rising at Greenwich till 8h. 14m. P.M.; it will reappear at 8h. 23m. P.M., at an angle of 241°. At 9h. 12m. the 6th magnitude star 53 Sagittarii will disappear at an angle of 37° from the vertex, and seven minutes later the 6½ magnitude star B.A.C. 6727 will disappear at an angle of 38° from the vertex—these two stars form a single star to the naked eye—53 Sagittarii reappearing at 10h. 12m. P.M., at an angle of 279° from the vertex, and B.A.C. 6727 9 minutes later, at an angle of 282° from the vertex. These three occultations take place during the partial eclipse, but in all three cases the disappearances and reappearances will take place at points of the lunar disc unobscured by the shadow of the earth. At 10h. 8m. P.M. on the 13th the 6th magnitude star 17 Capricorni will disappear at an angle of 14° from the vertex, and reappear at 10h. 46m. P.M., at an angle of 312° from the vertex.

ERRATUM.—On page 172 of KNOWLEDGE for June, second column, line nineteen, *for* ☌″·07 *read* ☌″·046.

A part of vol. xlix. of the "Memoirs" of the Royal Astronomical Society has just been issued, containing a paper by Mr. N. E. Green, "On the Belts and Markings of Jupiter." It is illustrated by twenty-one chromo-lithographic drawings of the planet. Mr. Green's great artistic skill enables him to represent the soft-edged cloud-like markings and the curious gradations of colour on the planet better than most other observers, and probably one would be correct in saying better than any other observer. The drawings on stone for the chromo-lithographs have all been made by Mr. Green.

Chess Column.

[Our Chess column has been placed in the hands of Mr. R. F. Fenton during the absence of Mr. Gunsberg, who has gone to play at the International Chess Tournament in New York. Mr. Gunsberg has now returned, but was not in time to undertake the preparation of this article.—EDITOR.]

THE NEW YORK INTERNATIONAL TOURNAMENT.

The tie between Max Weiss, the Vienna champion, and Michael Tchigorin, the Russian champion, has been played off, with the disappointing result that four games having been played, all ending in draws, the combatants have, in accordance with the rules of the tournament, equally divided the first and second prizes, of the respective values of 200*l.* and 150*l.* As in consequence of this lame and impotent conclusion there is no actual winner of the tourna-

ment, we presume the contemplated match for the championship of the world has fallen through. It must be allowed, however, that the literature of the game has been enriched by some splendid examples of play on the part of the European masters. We append a lively skirmish played between Messrs. Bird and Burn in the late tournament, together with two remarkably fine endings of games contested at the same gathering:—

KNIGHT'S GAME OF RUY LOPEZ.

WHITE. H. E. Bird.	BLACK. A. Burn.	WHITE. H. E. Bird.	BLACK. A. Burn.
1. P to K4	P to K4	12. Kt to Kt3	Kt to Q5 (*c*)
2. Kt to KB3	Kt to QB3	13. P × Kt	B × B
3. B to Kt5	Kt to B3	14. Q to Q2 (*d*)	P × KP
4. Q to K2 (*a*)	P to Q3	15. P × P (at K4)	P × P
5. P to B3	B to Q2	16. Kt × P	QR to Qsq
6. P to Q3	P to KKt3 (*b*)	17. Q to B2	Kt × P
7. QKt to Q2	B to Kt2	18. Kt × Kt	B × Kt
8. Kt to Bsq	Castles	19. B × P (*e*)	KR to Qsq
9. B to Kt5	P to KR3	20. P to B3	Q to R5 (ch)
10. B to K3	Q to K2	21. P to KKt3	Q × B
11. P to KR3	P to Q4	Resigns.	

NOTES.

(*a*) The best move here has long been the subject of controversy. Castling has been more generally adopted in the present tournament, but P to Q4 found many advocates.

(*b*) A favourite development with Mr. Burn.

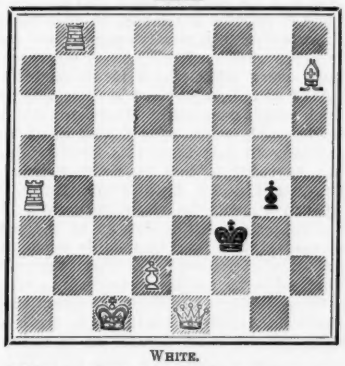
(*c*) Very ingenious, and the turning-point of the game.

(*d*) Q to QB2 would have been a better move; Mr. Burn takes instant advantage of the Queen's present bad position.

(*e*) In such a position it matters little what move is made, the game is hopeless.

PROBLEM BY HERR CAPRAETZ.

BLACK.



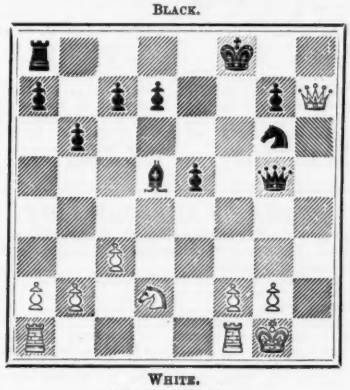
WHITE.

White to play and mate in two moves.
White, six pieces; Black, two pieces.

Position after Black's eighteenth move, in a game played at the tournament, Pollock *v.* Gunsberg. The former had the move, Mr. Gunsberg defending with the Fianchetto di Donna.

J. GUNSBERG.

BLACK.



WHITE.

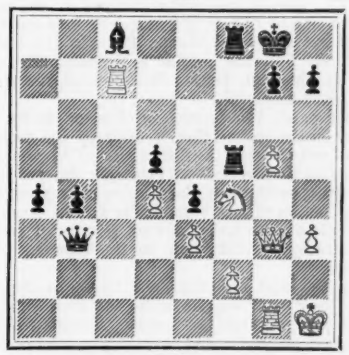
W. H. POLLOCK.

WHITE.	BLACK.
19. P to KKt3	K to B2
20. Q to R3	R to Rsq.
21. P to KB4	Kt × P
22. R × Kt (ch)	P × R
23. Q × P (ch)	K to Kt3.
24. Kt to K4	P × P
25. R to Ksq.	Q to R5
26. Kt to B2	Q to R8 (ch)
27. Kt × Q	R × Kt mate.

Position after Black's thirty-first move in one of the tourney games, Blackburne *v.* Lipschutz. The opening was the Queen's gambit, declined.

S. LIPSCHUTZ.

BLACK.



WHITE.

J. H. BLACKBURNE.

WHITE.	BLACK.
32. P to Kt6	P to R3
33. R × P (ch)	K × R
34. Kt to R5 (ch)	R × Kt
35. Q to B7 (ch)	K to B3
36. Q to Q6 (ch) and mates in 3 moves	

The match between Mr. Loman, Champion of Holland, and Mr T. Block, at the City of London Chess Club, is practically over. There is still an end-game pending, which is almost certain to end in a draw, leaving Mr. Block the winner of the match by 4 games to 2 games.

In the Spring Tournament at the same club, Mr. Woon has been declared the victor of No. 3 section, closely followed by Mr. E. O. Jones.

The competition for the special prizes presented by Messrs. Mocatta and Anger is still in progress, and Mr. E. O. Jones, Mr. Anger, and Mr. Hunt are abreast.

At the British Chess Club a match has lately been played between Mr. Wainwright and Mr. Ingoldsby of five games up, draws not to count. Mr. Wainwright drew the first game, and then won four in succession. Mr. Ingoldsby then resigned the match.

The sixth Congress of the German Chess Association commences on the 15th inst. The Masters' Tournament will probably last a fortnight. There are five prizes announced, viz.:—First prize, 50*l.*; second, 35*l.*; third, 25*l.*; fourth, 15*l.*; and fifth, 7*l.* 10*s.*

The Amsterdam Tournament, commencing on August 25, offers three prizes of the value of 33*l.* 10*s.*, 18*l.* 15*s.*, and 10*l.* 5*s.* It is hoped that a Chess Tournament will be arranged, to take place in Paris some time in August. An influential committee has been formed, and the prizes proposed are—first prize, 2,500 fr.; second, 1,000 fr.; third, 800 fr.; fourth, 600 fr.; fifth, 400 fr.; sixth, 200 fr. It is expected that the full programme will be soon issued.

ANSWERS TO CORRESPONDENTS.

Correct solutions to problem in our last number by E. W. Tarn, S. Anstey, J. Jenkins, and F. Gibbs.

W. HILLIER.—An excellent work on the openings is "Chess Openings," by E. Freeborough and the Rev. C. E. Ranken; Trübner & Co., London. Write to Mr. W. W. Morgan, Chess Publisher, 17 Medina Road, Upper Holloway, N., who has also just published an excellent collection of games from the New York Chess Congress, price one shilling.

XUM

Whist Column.

BY W. MONTAGU GATTIE.

AMERICAN LEADS.

(*Continued from page* 175.)

WE have already hinted that the system of leads which we described in the May number of KNOWLEDGE has been the subject of considerable controversy in whist circles. To many players, and particularly, no doubt, to those of mathematical tastes, there is something very attractive in the establishment of a code which marshals in scientific order and invests with a uniform meaning the various conventions as to leading from long suits that have, one by one, grown gradually into use, as experience in actual play has suggested them. Thus, in the last edition of "Cavendish," we find the author enthusiastically remarking:—"The more the American system is examined, the more thorough and perfect it will be found."

On the other hand, the system is objected to by some strong players, partly on the ground that it adds to the technicalities of the game, and so increases the difficulties of beginners, but more especially because they oppose on principle the growing tendency to formulate exact methods of play, urging with some force that the undue multiplication of such formulæ is apt to crush the life out of a game which, after all, depends on powers of ready inference and adroit strategy rather than on the rigorous observance of definite laws.

As regards the first objection, we have already said that the student may very well acquire sufficient knowledge of whist to enable him to play an intelligent rubber without troubling himself at all with American leads; and he would, in our opinion, do wisely to reserve their consideration until he has thoroughly grasped the main principles of the game. But to those who have already become fairly proficient, and whose faculty of observation is sufficiently trained for them to derive benefit from penultimate and antepenultimate leads and other recognised openings from suits of five or more cards, the new code is, as we believe, of great service, not only because it systematises, as already explained, the existing conventions, but also because it affords in many cases an easy means of obtaining information which would otherwise be beyond the reach of any but the finest players.

For example, A leads, as his original lead, the 7 of spades; Y follows with the 4; B (A's partner), holding queen knave only, plays knave; and Z plays 8. B can at once place king, 10, 9, of spades in A's hand, unless both the adversaries are calling for trumps. For, except in that case, A must have either deuce or trey of spades, and therefore has led from a suit of five cards at least, so that he does not hold the ace; and, as he must have three cards higher than the 7, they must be king, 10, 9. Hence it follows that Z is either asking for trumps or void of spades, and that Y has the ace. Now let us suppose that from a suit consisting of king, 10, 9, 7, 3, 2, A had led the lowest instead of the fourth best. It is clear that B would have been able to gather none of the valuable information we have mentioned; and, although he might by carefully observing the fall of the cards have arrived ultimately at the same conclusions, he could not have done so nearly as easily or as certainly as if A had followed the American rule.

To take one other instance. From king, queen, 8, 6, 4, A leads king, Y plays 7, B (holding ace, 9, 3) puts on the 3, and Z plays 2. A continues with the 6, Y plays 10, B plays ace, and Z plays 5. The queen of course would have been marked in A's hand whether he had led the 6 or the 4; but, by continuing with the original fourth-best, he shows B in addition (1) that he has the 4 (for no one else can hold it), and therefore that his suit consisted of five cards, and (2) that his other high card is the 8, for he must have two cards higher than the 6, one of them is the queen, and the other, since A has continued the suit with a small card, cannot be the knave, and must therefore be the 8.

The second of the arguments to which we have referred has much more weight. It is contended that the necessity of conforming to a stringent system of conventions tends to deaden the imagination, and furthermore to limit the scope for strategy and artifice. It must be conceded that the appearance of one or two false cards in the course of a hand may seriously interfere with the calculations of a player who always proceeds on strictly scientific principles; while, on the other hand, the man who is too intent on watching for refinements of leads is liable to overlook opportunities for a bold stroke or a successful ruse.

Not very long ago the writer was triumphantly assured by a gentleman who has probably played as many rubbers as any man living, and who is well versed in all that "the books" can teach, that playing whist occasioned him no mental effort whatever, but was to him "mechanical, purely mechanical." Those who are acquainted with this gentleman's style of play would scarcely be prepared to combat his assertion; and we fear that there are other practised players who regard the conventions of whist as the highest poetry of the game instead of being merely its alphabet. Indeed, it may be questioned whether the habit of playing according to rule does not tend to produce even in the best players some degree of insensibility to occasions when the rule may be departed from with advantage.

Thus, in the domain of whist, as in that of chess, we have an old and a modern school, the one relying mainly on strategy and ready wit, while the other aims at greater scientific accuracy, or, as some critics irreverently call it, "pip-counting." But it must not be forgotten that the objections which we have pointed out would, if pushed to their logical conclusion, assail the whole of the beautiful system of conventions which has raised whist to its present unique position among games of chance. The player with a talent for strategy will always stand on a higher level than the man who has no idea beyond dull conformity with routine; but strategy must have some facts to go upon, and for these it must look to "pip-counting."

Some of the leading opponents of the American code are men who can generally reckon on discovering for themselves in the course of the play nearly all that American leads can tell them; and they may not unnaturally view "with scornful, yet with jealous eyes," the invention of simpler means of information. It is probable that the "developments" introduced by the modern school are more useful to an indifferent player than to a good one; but the same thing may be asserted of other conventions now generally accepted, and notably of the call for trumps. Before the institution of the call, every one had to decide for himself whether a trump lead would be likely to suit his partner's hand, and players with a genius for the game had a marked advantage in this respect; whereas nowadays the information is generally open to any one who takes the trouble to observe what cards his partner plays. And, after all, seeing how much every whist-player is doomed to suffer from the shortcomings of an obtuse partner, is there any need to decry methods by which people who would otherwise play very badly are enabled to play tolerably well? Nor do we think that the good players have anything to fear from this levelling up, or that the game itself has anything to lose by being reduced to scientific principles. Opportunities for deep combinations, for brilliant strokes of play, can scarcely be diminished, even if they be not increased, by more precise indications as to the position of the cards, and the best players must inevitably come to the top, as heretofore. As already observed, it often becomes a question whether it is preferable to declare strength in a suit or to conceal it; and, while the necessity of deciding in certain cases whether to adopt or to avoid an American lead affords fresh scope for the exercise of judgment, we must depend on intuitive quickness of perception to determine whether the card actually led under such circumstances by partner or opponent is to be trusted or suspected.

In our next article we shall give a hand illustrating the American system of leads, and we shall conclude our review with some observations as to the management of trumps.

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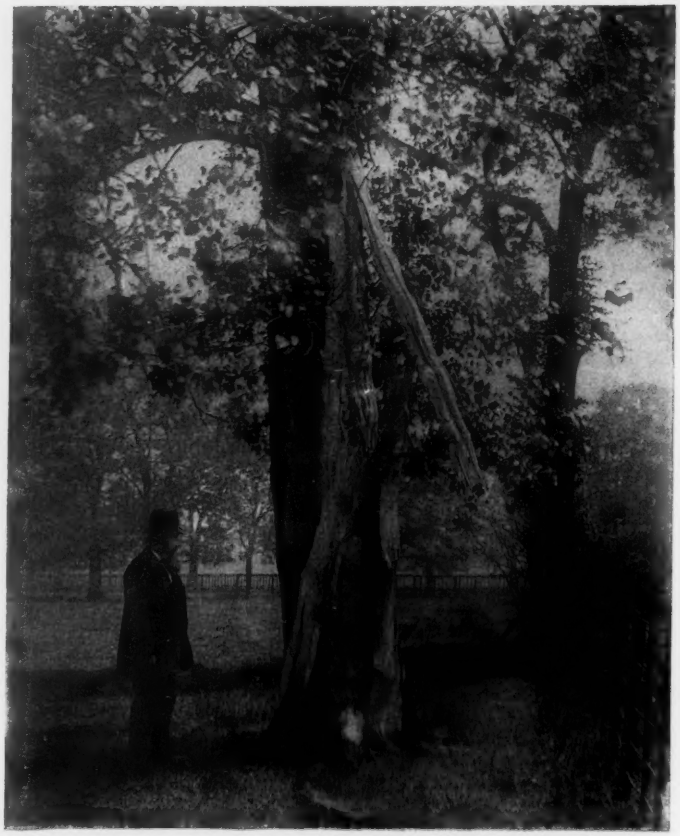
XUM

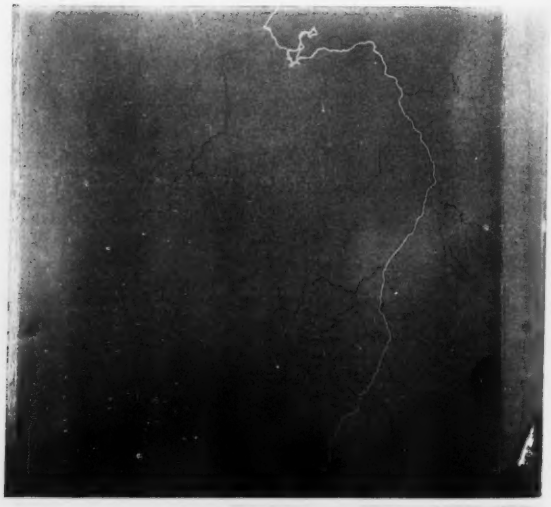
Scars and markings on a man struck by Lightning at Hampstead, on June 14th, 1888.

Poplar Struck by Lightning in Regent's Park, on 6th July, 1881.



Clothes worn by two men when struck by Lightning at Hampstead, on 14th June, 1888.

Oak shattered by Lightning at East Tisted, Hants, on 20th May, 1887.



Taken at Cambridge on 6th June, 1889, by the Rev. A. Rose, of Emmanuel College.

Shoes worn by children when struck by Lightning in Atcham Church, Shrewsbury, July, 1879.

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